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No. 6. Descriptions of the Palæozoic Fossils of New South Wales. By the late L. G. de Koninck, M.D. Pp. xiv, 298, 24 plates (4to., Sydney, 1898). Translated by Professor T. W. E. David, B.A., F.G.S., Mrs. David, and W. S. Dun.

No. 7. The Mesozoic and Tertiary Insects of New South Wales, pp. 12, 2 plates (4to., Sydney, 1890). By R. Etheridge, Junr., and A. Sidney Olliff.

No. 8. Contributions towards a Catalogue of Works, Papers, and Reports on the Anthropology, Ethnology, and Geological History of the Australian Aborigines, Part I, pp. 31 (4to., Sydney, 1890); Part II, pp. 49 (4to., Sydney, 1891); Part III, pp. 40 (4to., Sydney, 1895.) By R. Etheridge, Junr.

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No. 14. A Monograph of the Foraminifera of the Permo-Carboniferous Limestones of New South Wales, pp. 22, pls. 4 (4to., Sydney, 1905). By F. Chapman, A.L.S., and W. Howchin, F.G.S.

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PALÆONTOLOGICAL SERIES.

No. 5. The Permo-Carboniferous Invertebrata of New South Wales. Vol. II. The Pelecypoda. Part II. The Genus *Eurydesma*. By R. Etheridge, Junr., and W. S. Dun.

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DEPARTMENT OF MINES.

MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

E. F. PITTMAN, A.R.S.M., GOVERNMENT GEOLOGIST.

PALÆONTOLOGY, No. 5.

R. ETHERIDGE, JUNR., PALÆONTOLOGIST.

A MONOGRAPH

DEC 29 1892

OF THE

CARBONIFEROUS AND PERMO-CARBONIFEROUS INVERTEBRATA

OF

NEW SOUTH WALES.

PART II.—ECHINODERMATA, ANNELIDA, AND CRUSTACEA.

BY

R. ETHERIDGE, Junr.,

Palæontologist and Librarian to the Geological Survey of New South Wales; and Palæontologist to the Australian Museum, Sydney.

SYDNEY: CHARLES POTTER, GOVERNMENT PRINTER.

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Letter of Transmittal.

Geological Survey, N. S. Wales,
Department of Mines,
Sydney, 25 March, 1892.

Sir,

It becomes my duty to submit for publication the accompanying Memoir, No. 5, of the *Palæontological Series* of the Geological Survey, being Part II of the *Carboniferous and Permo-Carboniferous Invertebrata of New South Wales*, by Mr. Robert Etheridge, Junr., Palæontologist.

The present Memoir deals with the representatives—hitherto found in the above-named formations—of three Classes, viz., *Echinodermata*, *Annelida*, and *Crustacea*, and it will be found to comprise twenty-nine species, of which no less than seventeen species, new to science, have been named, figured, and described.

The Work is another illustration of the untiring industry of Mr. Etheridge in the domain in which his previous exertions have already made his name so well known amongst Scientists. The importance of such work in connection with the mapping of the Carboniferous areas of the Colony is too obvious to need comment by me, and it will lend additional interest to the Geological Survey of the Newcastle and Maitland Coal-field, which has recently been completed by Professor T. W. E. David, B.A., F.G.S., whose map and report will, it is hoped, be soon issued.

The illustrations reflect great credit upon the artist, Mr. G. H. Barrow, of the Australian Museum.

I cannot conclude without a tribute to the memory of my lamented friend and predecessor in office, the late Mr. C. S. Wilkinson, F.G.S., F.L.S., under whose direction the previous numbers of this Series were published,

and upon whose advice the Department succeeded in obtaining the services of Mr. Etheridge, the Author of this and several of the preceding Memoirs. Mr. Wilkinson's courteous and unassuming demeanour, as well as his large hearted sympathetic nature, will be remembered as long as any of those who enjoyed the privilege of his acquaintance survive him. The record of his scientific labours will endure much longer.

I have the honour to be,
Sir,
Your obedient servant,
EDWARD F. PITTMAN, A.R.S.M.,
Government Geologist.

Harrie Wood, Esq., J.P.,
Under Secretary for Mines.

Author's Preface.

The Second Part of the Monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales includes the Echinodermata, Annelida, and Crustacea known to the Writer.

The whole of the specimens figured, with the exception of five, are contained in the cabinets of the Mining and Geological Museum. For an opportunity of illustrating the first of the exceptions (*Phialocrinus nodosus*, Eth. fil., Pl. XIV, Figs. 4 and 5) thanks are due to the Trustees of the Australian Museum; similarly for the second (*Tribrachiocrinus corrugatus*, Ratte—Pl. XVI, Figs. 5–10); and for the third, the magnificent subject of Pl. XVIII, Fig. 1 (*Phialocrinus princeps*, Eth. fil.), to the Council of the Maitland Scientific Society; for the fourth (Radial plate, Pl. XX, Fig. 9), again to the Trustees of the Australian Museum; and for the fifth (*Phillipsia grandis*, Eth. fil., p. 128, Fig. 5), to Mr. D. A. Porter, Inspector of School Buildings, Tamworth.

Mr. John Waterhouse, M.A., Inspector of Schools, has, with his usual liberality, presented several specimens of Echinodermata to the Collection, and so has Mr. B. G. Engelhardt, of the Public School, Jamberoo, which have materially assisted in the elucidation of difficult problems. Two of the beautiful Star-fish (*Palæaster Clarkei* and *P. giganteus*) have been presented by Mr. T. Browne, of Ravensfield, West Maitland, and for the presentation of the peculiar Crinoid, *Phialocrinus? Stephensi*, Eth. fil., we are indebted to the Executors of the late Mr. David Berry, of Cooloomgatta. The Rev. W. H. Yarrington, M.A., has also lent an example of *P. Clarkei* for comparison. The remainder of the specimens were obtained under the direction of the late Mr. C. S. Wilkinson, Geological Surveyor-in-Charge, by the Collector, Mr. C. Cullen, or, under the superintendence of Prof. T. W. E. David, B.A., when surveying the Maitland District. The fine example of *Phialocrinus Koninckii*, Clarke (Pl. XVI, Fig. 1), was collected by Mr. E. F. Pittman, Government Geologist.

I am indebted for cordial services to my Assistant, Mr. W. S. Dun; for his accustomed skill in depicting the fossils to Mr. G. H. Barrow, of the Australian Museum; and for the Photo-lithographs to Mr. P. T. Hammond. As in Part I, the Plates have been reproduced by the Heliotype Process, at the Government Printing Office, by Mr. A. E. Dyer, under the direction of the Government Printer.

R. ETHERIDGE, Jnr.

I.—INTRODUCTION.

The distribution of the Permo-Carboniferous Echinodermata is equally fitful with that of the Actinozoa, and the life history of this Class would seem to have been governed by the same causes as those which yielded so powerful an influence on the latter. From a specific point of view the occurrence of Echinoderms in the rocks in question is rare; at any rate this would appear to be the case from the geological researches that have so far progressed. In two out of the three groups represented this would also appear to be the case numerically, for the Crinoidea is the only Class in which anything like a redundance of individuals predominated. This fact is only arrived at from the abundance of skeletal fragments in some deposits, chiefly stem joints, anything like perfect calices, not to speak of the entire organism being rare. In the Carboniferous rocks, or those beds below the Lower Marine Series, several horizons have been discovered at which extensive traces of Crinoid life have been found, chiefly consisting of stem fragments entering into the composition of limestones.

We are now, for the first time, made aware of the existence in our rocks of the Palæozoic section of the Echinoidea, whilst the Asteroidea, formerly known from the presence of one species, is now represented by three, and these of large size.

So far the Crinoidea are known to occur in the Carboniferous and the Upper Marine Series of the Permo-Carboniferous; the Asteroidea, in both the Lower and Upper Marine Series, but the Echinoidea only from the Upper Marine Series. The Cystoidea and Blastoidea are not represented at all in our New South Wales Carboniferous or Permo-Carboniferous rocks, although the latter class is known to occur in beds of the last-named age in Queensland.

I am not aware that the remains of Annelids have been before noted; and although the evidence is but meagre, sufficient is before us to raise a hope of future additions.

With regard to the Crustacea, two Orders are known to exist—the Ostracoda and Trilobita. The first occurs both in the Carboniferous and Permo-Carboniferous, the second only, so far as I have been able to ascertain, in the second division of this series of our rocks.

II.—DESCRIPTION OF THE GENERA AND SPECIES.

Sub-Kingdom—**ECHINODERMATA.**

Division—ECHINOZOA.

Class—**ECHINOIDEA.**

Order—**Palæchinoidea.**

Sub-order—**Perischoëchinidæ.**

Obs.—In addition to the specimens hereinafter described as *Archæocidaris? Selwyni*, and *Archæocidaris, sp.*, a few fragments of spines have been met with, but in no case sufficiently well marked or preserved to warrant description. A single plate has been found in the Permo-Carboniferous of the Rockhampton District, Queensland.

Family—ARCHÆOCIDARIDÆ.

Obs.—This family is represented in our Permo-Carboniferous rocks by one genus only. It is unknown from Western Australia, but a single plate impression has been found by Mr. C. W. de Vis, in the Gympie Series, of the Rockhampton District, Queensland.

Genus—ARCHÆOCIDARIS, *McCoy*, 1844.

(Synop. Carb. Lime. Foss. Ireland, p. 173.)

ARCHÆOCIDARIS ? SELWYNI, *sp. nov.*

Pl. XV, Figs. 1–3.

Sp. Char.—Test fully four and a half inches in diameter at the greatest periphery. Interambulacral plates very large, quite a quarter of an inch in diameter, with prominent rim-like edges; surfaces concave from the edges to the miliary rings, which, with the primary tubercles are large and

prominent; plates arranged in four and perhaps five series; if so, the central row much smaller than the others. Ambulacral areas apparently three-eighths of an inch wide. Teeth large and strong, quite two-thirds of an inch in length.

Obs.—So far as I am aware, the existence of the interesting group of the Perischoëchinidæ has not hitherto been recognised in the Permo-Carboniferous rocks of this Continent. The fine, although much maltreated, specimen now figured, was rescued from the *débris* of the Departmental Collection at the Garden Palace fire in 1882. Previous to this disaster a description of some utility might have been drawn up, but in the present state of the fossil this is hardly possible.

The portion remaining consists of rather less than the ventral half, with the "Lantern of Aristotle" *in situ*. The test was fully four and a half inches in diameter, and must have been that of a robust individual, but in its present state the approximate height cannot be arrived at. The positions of two of the ambulacra are indicated by faint impressions of the plates, and those of the others can be fixed by measurement. The two rows of plates appear to have been three-eighths of an inch wide, but all trace of the pores is quite lost.

The interambulacral plates were very large, fully half-an-inch in diameter, with prominent edges, and the surface between these and the miliary rings concave. There is, in relation to these plates, an obscure point, which I am not at present prepared to explain. The rows of plates in each inter-ambulacral area are certainly four, but in the middle line of the three best preserved areas, between the two contiguous rows of tubercle bearing plates, are smaller pieces devoid of tubercles. This central line of each inter-ambulacrum is also its most prominent position. The state of preservation is so indifferent that too much stress cannot be laid on this point, but from their appearance on three of the interambulacra one is led to regard this feature as a structural arrangement. In such a case it would have equal value with the somewhat analagous arrangement met with in *Perischodomus*, M'Coy,* and must be looked upon as of generic importance, and a new name coined for its reception. The characters of the interambulacral plates are, however, so manifestly those of *Archæocidaris* that the specimen is for the

* Ann. Mag. Nat. Hist., 1849, III, p. 253.

present placed in that genus, with the trivial name of *A.? Selwyni*, in honour of Dr. A. R. C. Selwyn, F.R.S., Director of the Geological and Natural History Survey of Canada, and formerly Director of the Geological Survey of Victoria, Australia. The teeth are large, quite two-thirds of an inch in length, and very strong.

Locality and Horizon.—Nowra, Shoalhaven River, Co. St. Vincent:—Nowra Grit (equivalent of the Muree Rock of the Hunter River Coal-field)—**Upper Marine Series.**

Archæocidaris, *sp. ind.*

Pl. XXII, Fig. 1.

Obs.—In all probability a second species of *Archæocidaris* exists in our Permo-Carboniferous rocks, as exemplified by the fragmentary specimen represented in Pl. XXII, fig. 1, for which we are indebted to Mr. John Waterhouse, M.A., Inspector of Schools, Dungog. The specimen consists of portions of eight rows of interambulacral plates, four close together, practically in apposition, separated from two of the others by the faint impression of an ambulacrum. The remaining portions of rows are at the opposite extremity. The more or less radiating manner in which these rows are disposed leads me to believe that the central unoccupied space of a lighter coloured matrix may represent one or other of the poles.

I believe this to be a species distinct from *A. Selwyni* on account of the more transverse shape of the plates, the almost square-hexagonal outline of those of the latter species being one of its chief characters. The primary tubercles of the present species are particularly well marked. One of the ambulacra is just indicated by the impressions of a few plates, but too imperfectly for description.

Locality and Horizon.—Quarry near road passing Dagworth, about five miles south of West Maitland, Co. Northumberland (*J. Waterhouse, M.A.*) :—**Upper Marine Series.**

Class—**ASTEROIDEA.**

Obs.—Starfish are not known to occur either in the Carboniferous or Permo-Carboniferous rocks of Western Australia, or Queensland.

Order—Encrinasteriæ.

Family—*PALÆASTERIDÆ.*

Genus—PALÆASTER, *Hall*, 1852.

(Pal. New York, ii. p. 247)

Obs.—The genus *Palæaster* ranges from the Upper Silurian to the Carboniferous, but its representation in rocks of the latter period is far more limited as regards species than in those of the former. The three species from the Permo-Carboniferous of New South Wales, now referred to *Palæaster*, although possessing the general features of the genus, differ in an important particular from Hall's original types, *P. matutina*[1] and *P. eucharis*.[2] In both of these, and in other Silurian and Devonian forms, the adambulacral plates, bordering the ambulacral avenues, are small and quadrangular, followed by large transverse marginal plates. In our Permo-Carboniferous species, on the contrary, the adambulacral plates (Pl. XV, Fig. 4) are transversely elongated, and occupy nearly the whole of the actinial surface on each side the avenues.[3] The marginal plates, in contradistinction to those of Hall's Silurian species, are here smaller and subdorsal in position (Pl. XIV, Fig. 2). The question now presents itself, of what value in a classificatory sense is this character? Hall lays particular stress on the position of these plates on the actinial side of *Palæaster*. He says[4] it "has two ranges of plates on each side of the ambulacral groove; marginal and adambulacral plates on the lower side, besides ambulacral or poral plates. The upper or dorsal side has three or more ranges of plates." In the case of our specimens, only one set of plates, excepting those of the ambulacral grooves, are, as before stated, absolutely actinial; the marginal are strictly so, or, at the least, sub-dorsal. Under these circumstances, I

[1] Twentieth Ann. Report N. York State Cab. Nat. Hist., 1867, p. 283, t. 9, f. 2.

[2] *Loc. cit.*, p. 287, t. 9, f. 3, 3^a, 3^b, and 4.

[3] This feature is also visible in De Koninck's figure, Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, t. 7, f. 6^a.

[4] Twentieth Ann. Report N. York State Cab. Nat. Hist., 1867, p. 283.

purpose distinguishing our Australian species under the sub-generic name of *Monaster*.[1] The genus *Urasterella*, McCoy,[2] likewise only possesses the adambulacral plates on the ventral surface; but in this case neither are there marginal plates, so far as I can glean from Sir F. McCoy and the late Professor Forbes's descriptions.

Palæaster (Monaster) Clarkei, *De Koninck*.

Pl. XIV, Figs. 1 and 2; Pl. XV, Fig. 4.

Palæaster Clarkei, De Koninck, Foss. Pal. Nouv.-Galles du Sud., Pt. 3, 1877, p. 166, t. 7, f. 6, 6ª.

Sp. Char.—Body large, shortly stellate, robust; disc large, strongly pentagonal, raised above the level of the tumid rays, straight walled, surface flat, or a little concave, bearing five tubercles. Rays broad, thick, and tumidly petaloid; margins convexly curved; abactinial surface arched; actinial surface flat or somewhat concave; interbrachial areas sharply V-shaped. Abactinial plates hexagonal, thick, and convex, arranged in three rows, eight to ten in a row, the median the smallest, and alternating with the lateral series, which are transversely elongated. Ambulacral avenues rather broad and elongately petaloid, gaping, and deep; ambulacral plates small, and apparently in two rows. Adambulacral plates eighteen to twenty in a row, large, very transverse, narrow, and convex. Marginal plates subdorsal in position, convex, narrow, and triangular, more or less resembling the plates of the abactinial surface, but differing in ornament. Madreporiform plate large, oval, situated on the straight wall of the disc. Oral plates not preserved. Ornament of plates tubercular, the abactinial ray plates being covered with densely packed small granules radiately arranged, but the marginal plates bear large tubercles, which carry short, fine, projecting spines.

Obs.—There is doubtless much truth in the late Prof. de Koninck's statement that *Palæaster Clarkei* is one of the largest of the known Palæozoic starfish; but that it is not the largest is shown by comparison with the two succeeding species, nor does *P. Clarkei* precisely resemble any species of the genus with which I am acquainted.

---

[1] From the one or single row of adambulacral plates on each side of an ambulacral avenue.

[2] Brit. Pal. Foss., 1851, Fas. I, p. 59. *Stenaster*, Billings, is generally said to be identical with this. (Hall, *Loc. cit.*, p. 289.)

The plates termed ambulacral by De Koninck are in reality the adambulaeral, the ambulacral elements being contained in the ray avenues ; but the tubercle-bearing auxiliary plates mentioned in his description I have not seen.

The only specimen showing the actinial surface is much destroyed, and does not display this portion distinctly. In De Koninck's figure of this aspect of the body the oral plates each appear to be composed of two small, rounded, tubercle-like halves. The disc, when viewed from the abactinial side, is seen to be prominent and straight-walled externally, either flat or concave on its upper surface, with five node-like projections answering to each median interradial line.

The madreporiform plate has been seen in two examples. It is a large oval piece, placed on the steep wall of the disc, and between two rays in the usual manner, with the component radiating laminæ distinctly visible.

In one specimen the arms are two and four-eighths inches long, and in another example one and five-eighths inches long from the centre of the body.

I have not seen an ambulacrum with the plates *in situ*, but De Koninck's figure (*Loc. cit.*, Pl. VII, Fig. 6[a]) represents them as opposite, a character which, if correct, would not only remove the species from *Palæaster*, but also from the Enerinasteriæ.

Very few Carboniferous species of *Palæaster* have been described. One has been figured [1] by Prof. Trautschold from the Russian Carboniferous Limestone as *Palæaster montanus*, Stschurovsky, sp., but the size and general proportions are so different to ours that the comparison need not be carried further. Mr. S. A. Miller has also described a *Palæaster* from the Keokuk Group of the American Sub-Carboniferous System, under the name of *P. crawfordsvillensis* [2], but the description is not within my reach.

Cribellites carbonarius, G. Tate [3], the Carboniferous Limestone species met with in Northumberland (England) is also a small form, with rays only 1·5 inch in length. The rays are rounded and lanceolate, with the dorsal surface covered with tubercles.

---

[1] Kalkbruche von Mjatschkowa, Pt. 3, 1879, p. 9, t. 2, f, 2*a* and *b*.

[2] Journ. Cincinnati Soc. Nat. Hist., 1880, II (*fide* S. A. Miller).

[3] Report Brit. Assoc. Adv. Sci. for 1863 [1864], Pt. 2, p. 88.

Locality and Horizon.—Russell's Shaft, Farley, Co. Northumberland (*The late Rev. W. B. Clarke*) :—Upper Marine Series; Nicholson's Quarry, near north-east corner of Owen's 1,100 acres, near West Maitland, Co. Northumberland (*Prof. T. W. E. David, B.A., Rev. W. H. Yarrington, M.A.*, and *Mr. T. Browne*) :—Lower Marine Series.

The first locality is a very typical and interesting one, being referred to by the late Rev. W. B. Clarke, F.R.S., in a "Section of Coal Pits at Stony Creek, New South Wales, near West Maitland,"[1] in the third bed from the surface, in Pit B. His note is as follows :—"Grey grit and conglomerate of quartz porphyry, &c., sandstone and soapy clay, muddy and blue; consisteney variable, with Spirifer, Fenestella, Conularia, Orthoceras, Asteridæ, &c." The specimens described by Prof. de Koninck were also from the same locality and horizon.[2]

Palæaster (Monaster) Stutchburii, *sp. nov.*

Pl. XIII, Fig. 1.

Sp. Char.—Body elongate; disc probably of medium size, but general proportions unknown. Rays long, very slowly tapering, straight sided, forming with one another an angle of from 60° to 75°; abactinial surface moderately convex, bearing several (five or six) rows of small convex polygonal plates, inclusive of the marginal pieces, and becoming much crowded at the apices of the rays, where they form oblique rows; marginal plates strong, short, thick, high, or somewhat pyramidal, and subhexagonal in outline. Actinial surface more or less flattened; avenues narrow, straight sided; ambulacral plates unknown; adambulacral plates transversely oval, thick, and arched, clothed with short, subulate, stout spines, arranged in about three alternating rows; oral plates very small, the two halves of each, pustuliform. Madreporiform plate unknown.

Obs.—*Palæaster Stutchburii*, although vieing with *P. Clarkei* in size is a straight rayed, and non-petaloid form, of the true *Palæaster* outline, and so differing from the latter, as well as in the increased number of plates on the abactinial surface.

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[1] Sedimentary Form. N. S. Wales, Fourth Edition, 1878, Vert. Section 1 (3rd plate). (8vo. Sydney. By Authority, 1878.)

[2] Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 168.

The spines clothing the adambulacral plates are subulate and short, measuring about three millimetres in length, and are ranged in three subalternating rows, the inner row, in each case, bordering the edge of the ambulacral avenues, but the rows of spines increase in number in the angles between the rays. In the present condition of the fossil, the spines are represented only by impressions. I believe they were delicately striate, but this is open to confirmation. The rays were as much as three inches long, and at the base three quarters of an inch wide.

Locality and Horizon.—Ravensfield Quarry, near Farley, Co. Northumberland (*Mr. T. Browne*) :—**Lower Marine Series.**

Palæaster (Monaster) giganteus, *sp. nov.*

Pl. XII.

Sp. Char.—Body large, extended, abactinial surface unknown. Rays long, from three to three and a-half inches, narrow in proportion to their length, barely three quarters of an inch in transverse measurement, widely separated at their bases, with a diverging angle varying from 75° to 90°, decreasing in width towards their apices but slowly, comparatively straight sided ; avenues narrow and deep. Marginal plates in the angles of the rays very large, transversely elongated, arched, and with more or less flattened surfaces, and rapidly decreasing in size along the margin of the rays. Adambulacral plates comparatively small, transversely elongated, convex, each bearing a row of prominent "primary" tubercles (probably more than three in a row), supporting strong spines, at least three millimetres in length ; oral plates very large, the twins in each case forming a somewhat cordate plate.

Obs.—I have separated the present form from the preceding species for three reasons. In the first place, the general proportions of the Starfish are quite different, especially in the size of the disc and length of the rays. In the second, the angle of divergence of the rays differs greatly from that of *Palæaster Stutchburii* ; in the former it is from 60° to 75°, in the present species from 75° to 90°. Thirdly, the form of the oral plates is here very different, and if I mistake not so also are the marginal plates. The greater angle of divergence of the rays leaves a much larger space between the bases of the latter, occupied by the large transversely elongated plates previously

referred to. In *P. giganteus* the corresponding plates of the body, it is true, are hid by spine impressions, but there is, practically speaking, no room for similarly large structures, and on this ground their absence is conjectured.

The oral plates are certainly very large, and quite different from the small node-like bones in *P. Stutchburii*. In all probability the adambulacral plates will be found to be smaller than those of the last-named fossil, but to possess larger and better developed tubercles. In fact, the latter have much the appearance of the primary tubercles of *Archæocidaris*.

As regards the extent of the body, *P. giganteus* is even a larger species than *P. Clarkei*, measuring no less than seven inches from the apex of one ray to that of another across the disc.

Locality and Horizon.—Ravensfield Quarry, near Farley, Co. Northumberland *(Mr. T. Browne)* :—Lower Marine Series.

Division—PELMATOZOA.

Class—CRINOIDEA.

Obs.—The first Writer to chronicle the remains of this Class in the Permo-Carboniferous rocks of New South Wales was Sir F. McCoy,[1] who brought to notice the interesting, and apparently aberrant *Tribrachiocrinus, Clarkei*. Later, the presence of the United States Exploring Expedition, under the orders of Commander Charles Wilkes, U.S.N., afforded Prof. J. D. Dana, Naturalist to the Expedition, the opportunity of examining some portions of the coast districts of New South Wales, resulting in the discovery of some very strange plates, to which he applied the generic name of *Pentadia*.[2] These will be referred to in detail later on.

As the original collection of the late Rev. W. B. Clarke, F.R.S., afforded Prof. McCoy the first introduction to our Permo-Carboniferous Crinoids, so the second, accumulated by the same energetic Geologist, enabled the late Prof. L. G. de Koninck to advance our knowledge[3] by adding to the

[1] Ann. Mag. Nat. Hist., 1847, XX, p. 228.
[2] Wilkes' U. S. Explor. Exped., 1849, X (Geology), p. 712.
[3] Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, pp. 158–166.

list one of the largest fossil Crinoids known, *Cyathocrinus Koninckii*, Clarke, to redescribe *Tribrachiocrinus Clarkei*, McCoy, and to indicate the probable presence of other genera from their fragmentary remains.

In 1884 the list was increased by the late Mr. Felix Ratte describing a second species of *Tribrachiocrinus*;[1] and lastly, by Messrs. Wachsmuth and Springer, in their most comprehensive "Revision of the Palæocrinoidea," defining[2] *Tribrachiocrinus* according to the more recently accepted nomenclature, and relegating it to its proper place in the classificatory scale.

The abundance of Crinoid skeletal remains has already been referred to, particularly stem joints, and portions of the united column; in some cases, as in the Carboniferous Limestone of other parts of the world, forming the great mass of entire beds. Such deposits have been found by the Collector near Ulladulla; at the head of Flat-rock Creek, Nowra Hill; Rouchel Brook, about six miles from the Hunter River Junction, and other places.

At Flat-rock Creek the portions of stems obtained are fairly large, and resemble those of *Poteriocrinus crassus*, of the European Carboniferous Limestone.

The chief horizons from whence determinable Crinoids have been obtained are the Muree Rock, of the Upper Marine Group in the Hunter Valley, and its southern equivalent, the Conjola Grits of the Shoalhaven District, and a few localities in the more strictly Carboniferous area north of the River Hunter.

One very strong fact, however, stands prominently forward, that so far as our field operations have as yet disclosed, the genera *Tribrachiocrinus* and *Phialocrinus* are not known out of the Permo-Carboniferous, and are particularly characteristic of the Upper Marine Series.

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[1] Proc. Linn. Soc. N. S. Wales for 1884 [1885], IX, Pt. 4, p. 1158.

[2] Revision of the Palæocrinoidea, 1886, Pt. III (2), p. 251 (175).

Order—Coadunata.

Family—ACTINOCRINIDÆ.

Genus—ACTINOCRINUS, *Miller*, 1821.

(Nat. Hist. Crinoidea, p. 90.)

Obs.—In Queensland, the impressions of a few highly ornamented plates have been found in the Star Series of Corner Creek, and Gympie Series of the Rockhampton District, which are provisionally referred to this genus.[1]

ACTINOCRINUS, *sp. ind.*

Pl. XX, Figs. 6 and 7.

Obs.—The late Prof. de Koninck described an internal crushed cast from Glen William, referring it to Miller's *Actinocrinus polydactylus*[2] of the European Carboniferous Limestone.

The only specimens that have come under my notice referable to *Actinocrinus* are the subjects of Pl. XX, Figs. 6 and 7. The first of these (Fig. 6) is a portion of a calyx, an internal cast, showing the three basal plates and some of the primary radials, particularly a large heptagonal and contiguous hexagonal plate. The crushed example is in all probability the same species, and I believe them both to be identical with De Koninck's *A. polydactylus*. Their identity, however, with the European species of that name is, I think, very problematical, as all the specimens lack the highly ornate plates of the latter. De Koninck's figure and our Fig. 7 show no ridges on the plates at all; although on our Fig. 6 four principal ridges are to be seen, but the other plates are quite plain. Under these circumstances it is better, I believe, to leave the specific identification of these specimens an open question until others in a better state of preservation throw further light on the subject.

In addition to the plates described by De Koninck, Prof. F. McCoy had previously noted the occurrence of "fragments of pelvic plates of this genus" in the Dunvegan Shale.[3]

Locality and Horizon.—Greenhills, Paterson to Dungog Road, Co. Durham (*C. Cullen*) :—Mirari Limestone, Carboniferous.

[1] Geol. and Pal. Queensland and New Guinea, *in lit.*, t. 7, f. 9.
[2] Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 160, t. 6, f. 3.
[3] Ann. Mag. Nat. Hist., 1847, XX, p. 229.

Genus—PERIECHOCRINUS, Austin, 1842.

Periechocrinites, Austin, Ann. Mag. Nat. Hist., 1842, X, p. 110.

,, Austin, *Ibid*, 1843, XI, p. 203.

Saccocrinus, Hall, Pal. N. York, 1852, II, p. 205.

,, Meek and Worthen, Illinois Geol. Report, Pal., 1868, iii, p. 347.

Periechocrinus, Wachsmuth and Springer, Revision of the Palæocrinoidea, Pt. 2, 1881, p. 127 (301).

Obs.—A single imperfect specimen is provisionally referred to this genus of the Actinocrinidæ, from its close concordance with the general appearance and order of the plates of those forms termed by many American Palæontologists *Saccocrinus*, which were united by Messrs. Meek and Worthen with *Periechocrinus*, Austin.

Periechocrinus indicator,[2] *sp. nov.*

Pl. XXII, Fig. 4.

Obs.—Portions of two basals are preserved, surmounted by three hexagonal first radials, much longer than wide, and subangular in the direction of their longest diameter. The middle radial bears, evidently in the direct line of a ray, a second radial, also hexagonal, but less vertically elongated than the first. This again supports a third radial, the length and breadth of which is about equal, although hexagonal in shape. On the third radial are placed two smaller secondary radials of doubtful form, arising from imperfect preservation. The first inter-radial plate is quite as large, if not larger, than the second radials, and is hexagonal in outline. It is surmounted by two second inter-radial plates, apparently heptagonal, and these support two other rows of smaller plates of doubtful form, arising from their rather crushed condition. A similar structure to that now described is repeated in the inter-radius on the opposite side of the centrally-placed radial.

The specimen consists of a portion of an internal cast, on which the positions of the sutures are represented by raised lines. The general arrangement of the plates indicates that it is a member of the Actinocrinidæ, whilst

[1] Emended, Wachsmuth and Springer, Revision of the Palæocrinoidea, 1881, Pt. II, p. 130.
[2] Indicative of the presence of the genus in our rocks.

the partially ob-conic or urn-shaped outline which the calyx evidently possessed originally indicates *Periechocrinus* (*Saccocrinus*), or *Strotocrinus*, or some other near ally, as its resting place. From the list of species given by Wachsmuth and Springer, *Periechocrinus* appears to be essentially an Upper Silurian genus, with the exception of two American Carboniferous species, *P. amplus*, M. and W., sp., and *P. Whitei*, Hall, sp., to neither of which does our species bear any great specific resemblance. It is, however, with an American Crinoid from the Niagara Group, *P.* (*Saccocrinus*) *Christyi*, Hall, sp.[1], that our Permo-Carboniferous fossil agrees so closely in the form of its plates and outline of the calyx, and also with many of the species so beautifully figured in Angelin's posthumous work[2] on the Silurian Crinoids of Sweden.

An equally strong resemblance exists between *P.* (*Saccocrinus*) *indicator*, and the American Carboniferous genus *Strotocrinus*, which agrees "exactly with *Actinocrinus* in the number and arrangement of the pieces composing all that part of the body below the divisions of the rays."[3] *Strotocrinus regalis*, Hall, sp.,[4] possesses the same ob-conic outline and succession of radials and inter-radials, but there is about our specimen no trace of the characteristic horizontally expanded rim of the former genus, and without which it would not be possible to employ *Strotocrinus* for the reception of *P. indicator*.

One of the elevated ridges of the radials which pass from plate to plate in *Periechocrinus* is indicated in our specimen by a marked angularity of the surface.

Locality and Horizon.—Chalky Gully, Wollumba River, Co. Gloucester (*Pres. E. Twynam, Chief Surveyor*) :—? Carboniferous.

Periechocrinus ? *sp. ind.*

Photo-litho., Fig. 1.

Obs.—Some flattened and decorticated plates, more or less apposed to one another, probably represent either another species of this genus, or simply an *Actinocrinus*. The specimen is, however, of interest from its geological position.

[1] See Illinois Geol. Report, Pal., 1868, III, p. 347, t. 5, f. 1.
[2] Iconographia Crinoideorum in Stratis Sueciæ Siluricis fossilium (folio, Holmiæ, 1878).
[3] Meek and Worthen, Illinois Geol. Report, Pal., II, 1866, p. 189.
[4] See Illinois Geol. Report., Pal., 1866, II, p. 192, f. 7, t. 16, f. 6*a* and *b*.

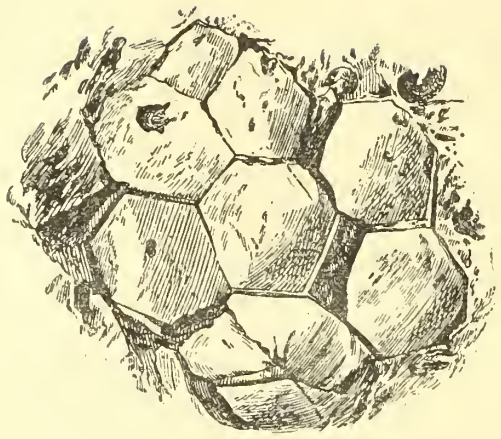

Fig. 1.

The almost complete basals are visible, three hexagonal first radials, a second radial, and two first inter-radials, also hexagonal. The radials and inter-radials are all higher than wide. The resemblance in general to *P. indicator* is strong, although the specific distinction is evident.

Locality and Horizon.—Greenhills, Paterson to Dungog Road, Co. Durham (*J. Waterhouse, M.A.*) :—Mirari Limestone, Carboniferous.

Family—PLATYCRINIDÆ.

Obs.—The presence of this family depends upon the discovery of some fragmentary remains at Glen William, Burragood, and at a locality between the River Hunter and the Rouchel Brook. These consisted of portions of a column and a small basal cup referred by De Koninck to *Platycrinus lævis*, Miller, or an allied species[1].

The basal plates in *Platycrinus* are three in number, but in the figure cited there are four distinctly shown, subdivided in a sufficiently perplexing manner to leave the question of identity in some doubt.

No member of this family is known to me from Western Australia; but the Middle Bowen Group, near Mount Britton Township, Queensland, has yielded a nut-shaped calyx, partly preserved, to which I have given the name of *Platycrinus? nux* [2].

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[1] Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 160, t. 6, f. 6, 6*a*.
[2] Geol. and Pal. Queensland and New Guinea, *in lit.*, t. 38, f. 3.

Order—INADUNATA.

Family—SYNBATHOCRINIDÆ.

Obs.—Prof. de Koninck described a small calyx under the name of *Synbathocrinus ogivalis*[1], from Burragood on the Paterson River. It would appear to be easily detected by two folds or ridges ornamenting the radial plates. De Koninck speaks of the basal plates as of one piece. They are, however, three in number, the sutures being obliterated by anchylosis. On comparing his *S. ogivalis* with the British species, *S. conicus*, De Koninck speaks of the latter as "la seule espèce du genre actuellement connue," but this contrasts strangely with a previous statement, "comme dans toutes les espèces de ce genre" (*i.e.* of *Synbathocrinus*). As a matter of fact, Messrs. Wachsmuth and Springer enumerate[2] no less than ten species which were known at the time Prof. de Koninck's Work was written.

I have not personally met with *S. ogivalis*. The horizon from which it was obtained will be within the Carboniferous.

Family—CYATHOCRINIDÆ.

Obs.—We do not possess any certain evidence of the presence of members of this family in our Carboniferous or Permo-Carboniferous rocks. Prof. McCoy noticed some large columns in the Rev. W. B. Clarke's collection "apparently of *Cyathocrinus*," from the limestone at Wagamee, and Wollamhoola.[3]

Family—POTERIOCRINIDÆ.

Obs.—The presence of the type genus of this family is evinced, according to the late Prof. de Koninck, by the occurrence of two plates. One of these is a basal, and the other a radial. The former, says the describer, may belong to *Poteriocrinus tenuis*, Miller[4], and the latter to *P. radiatus*, Austin[5], "or they may both belong to the same species." The fragments come

[1] Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 158, t. 6, f. 1*a–b*.
[2] Revision of the Palæocrinoidea, 1866, Pt. III (2), p. 166.
[3] Ann. Mag. Nat. Hist., 1847, XX, p. 229.
[4] Pal. Foss. Nouv.-Galles du Sud, 1877, Pt. 3, p. 159, t. 6, f. 7.
[5] *Loc. cit.*, t. 6, f. 2.

from the limestone at Burragood, on the Paterson River, and in Europe are characteristic of the Carboniferous Limestone. Specimens of this nature, although fragmentary, and sometimes difficult of determination, are of importance geologically, as indicating the probable presence of an otherwise unrecorded genus in our Permo-Carboniferous rocks.

The Poteriocrinidæ is however chiefly represented with us by the genus *Tribrachiocrinus*, McCoy. In Queensland a possible *Poteriocrinus* will be described[1] as *P.? Smithi*, Eth. fil., in memory of the late Mr. James Smith, of the Geological Survey of Queensland. Like so many of the fossils from that Colony, the state of preservation does not allow of an exact generic determination being made. In addition to this fossil, the impressions of large stems have been found in the Gympie Series of the Rockhampton District[2], very similar to some of those from Flat-rock Creek, Ulladulla, Shoalhaven District. As in the case of the latter, the Queensland specimens are almost indistinguishable from the stems of *Poteriocrinus crassus*, Miller. Other fragmentary fossils found during the progress of the Queensland Geological Survey, will be described in the work cited below, but it is not necessary to quote them in detail now.

Genus—TRIBRACHIOCRINUS, *McCoy*, 1847.

Tribrachyocrinus, McCoy, Ann. Mag. Nat. Hist., 1847, XX, p. 228.

Pentadia (pars), Dana, American Journ. Sci., 1847, IV, p. 152.

Pentadia (pars), Dana, Wilkes' U.S. Explor. Exped., 1849, X (Geology), p. 712.

Tribrachyocrinus, Pictet, Traité de Pal., 1859, IV, p. 321.

Tribrachyocrinus, Ratte, Proc. Linn. Soc. N.S. Wales for 1884 [1885], IX, Pt. 4, p. 1158; *Ibid* for 1886 [1887], I (2), Pt. 4, p, 1069.

Tribrachiocrinus, Wachsmuth and Springer, Revision of the Palæocrinoidea, Pt. III (2), 1886, p. 250 (174).

Tribrachiocrinus, Bather, Ann. Mag. Nat. Hist., 1890 V (6), p. 385, t. 14, f. 35.

Gen. Chars.—Dorsal cup globose, composed of heavy plates. Infrabasal plates three, comparatively large; two of them larger than the other, and pentagonal, but not of equal size; the smaller piece placed in a vertical line with the anterior radial. Basal plates five, extremely large, very irregular

[1] Geol. and Pal. Queensland and N. Guinea, *in lit.*, t. 8, f. 1.
[2] Geol. and Pal. Queensland and N. Guinea, *in lit.* t. 7, f. 6.

in form; the posterior one heptagonal, and larger than any of the rest; that to the left pentagonal; the three others hexagonal; upper side in four of the plates angular, in the other truncate, supporting the right postero-lateral radial. Radial plates five, irregular in form and size, the postero-lateral considerably smaller than the others; two posterior radials as well as the anterior one pentagonal, truncate above, and supporting a short subquadrangular costal; the two anterior ones hexagonal, angular above, supporting on each side an arm; line of articulation between the three former radials and their respective costals is widely gaping, and the mode of articulation is similar to that of all later Poteriocrinidæ; the two other radials, which have angular upper faces, are slightly constricted along their upper ends so as to indicate an anchylosis of costals and radials. Costals, although short, are twice as wide at their union with the radials as along their upper ends, which are truncate and moderately concave, each supporting a single arm; azygous[1] plate is unusually large, pentagonal, placed obtusely between the posterior basal and right postero-lateral radial; its upper angle, which extends almost to the top of the radials, is slightly truncated, and supports the first plate of the ventral tube, and its left upper side abuts against a large pentagonal anal plate. Column apparently small and circular. (*Wachsmuth and Springer*).[2]

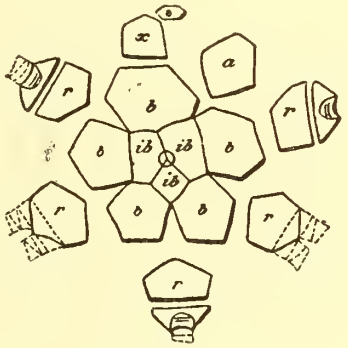

Fig. 2.

Obs.—This "singular crinoid," as Sir F. M'Coy aptly termed it,[3] or as Prof. de Koninck said,[4] "genre un peu anomal," was little understood until the appearance of the third part of Messrs. Wachsmuth and Springer's "Revision of the Palæocrinoidea."

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[1] *Azygous*, unpaired; or, parts that are apparently single, or have no symmetrical fellow.
[2] Slightly emended, R. Etheridge, junr., 1892.
[3] Ann. Mag. Nat. Hist., 1847, XX, p. 228.
[4] Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 161.

"The generic name *Tribrachyocrinus*," said the late Mr. Felix Ratte,[1] "was proposed by Professor M'Coy on the supposition that there were only three arms; but if, according to Wachsmuth and Springer, the two anchylosed brachials supported two arms each, more than mere rudimentary, then our fossil would have had three large and four smaller arms. This being so, the name etymologically considered is now a misnomer; nevertheless it conveys to the mind the notion that there were three conspicuous arms."

Examples of the type species are usually more or less distorted, produced more towards the posterior side than even the unsymmetrical arrangement of the plates would warrant. Such, however, is not the case in *T. corrugatus*, Ratte. This asymmetry is well expressed by M'Coy, who says, "The cup is not symmetrical in form, like that of other Crinoids, but is, as it were, humped on one side."

The plates of the calyx have been hitherto described by M'Coy, De Koninck, and Ratte as three in the articular ring, five in the succeeding ring, followed in the next tier by three radials, three interradials, and one or two anal plates. To these Ratte has added costals. Messrs. Wachsmuth and Springer, on the other hand, from an examination of a cast of *T. corrugatus*, supplied to them by the late Mr. Ratte, inferred that the third ring of plates "was composed of seven pieces, of which five were radials, the two others azygous plates, but that none of them are interradials. In three of the radials, the articulating faces form a straight horizontal line, and only these plates are opposed by regular brachials; the two others, those of the two antero-lateral rays being angular and higher at their distal ends."[2] After a very careful examination of all the specimens within my reach, I must express my entire concurrence with their view, so far, of the calyx structure of *T. corrugatus*, and I am able to state that precisely the same features are observable in that of *T. Clarkei*. The cause of the asymmetrical posterior side of the last-named species will naturally be inferred from the reading of its structure by the light of Wachsmuth and Springer's remarks. The region of the anal plates in the majority of Palæocrinoids seems to be the point of least resistance, and the "humped on one side" appearance described by M'Coy is simply caused by the peculiar form of the posterior basal, as shown by De Koninck,[3] and the displacement, to a

[1] Proc. Linn. Soc. N.S. Wales for 1886 [1887], I (2), Pt. 4, p. 1075.
[2] Revision of the Palæocrinoidea, 1886, Pt. III (2), p. 250 (174).
[3] Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 162.

greater or less extent, of the anal and large azygous plate. It is not, however, caused by the introduction of these plates, as Sir F. M'Coy suggested, "by the interpolation of the large irregular intercostal . . . . . and the second costal."[1]

A marked diversity exists between the descriptions of the form of the basal plates and those of the second ring, as given by M'Coy and Wachsmuth and Springer on the one hand, and De Koninek and Ratte on the other. De Koninck figured the anterior basals as pentagonal—they are hexagonal as figured by M'Coy, and described by Waehsmuth and Springer,—but the left posterior basal as pentagonal, and the right posterior basal as hexagonal, wherein he was right. The posterior basal De Koninck figured as hexagonal, whereas it is heptagonal. Ratte was correct in his description of the anterior basals as hexagonal, and the left posterior basal as pentagonal, but on the other hand, he called the right posterior basal heptagonal instead of hexagonal, and the posterior as octagonal instead of heptagonal. By M'Coy, and Wachsmuth and Springer, the description of these plates is correctly rendered. In the more recent nomenclature of Mr. F. A. Bather,[2] the azygous plate of Wachsmuth and Springer becomes the radianal, or as the late Dr. P. H. Carpenter expressed it, a radial "that has assumed anal functions." The anal plate is then termed by Mr. Bather the brachianal. The argument adduced by him in support of this change of nomenclature is too long for reproduction here, but a perusal of his remarks on the "Anal Plates" in his paper on British Fossil Crinoids"[3] will well repay the student. I have, however, taken the liberty of reproducing his dissection of the anal region of the *Tribrachiocrinus* calyx. The outline of the plates as given in his diagram in chief is strictly accurate.

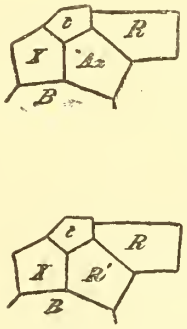

Fig. 3.

[1] Ann. Mag. Nat. Hist., 1847, XX, p. 228.
[2] Ann. Mag. Nat. Hist., 1890. V (6), p. 333, t. 14, f. 35.
[3] *Ibid*, p. 319.

The following table shows the equivalent terms for the plates in the calyx of *Tribrachiocrinus* used by the Authors who have written on the genus, including those now employed:—

TABLE showing equivalent terms for the plates in the calyx of *Tribrachiocrinus* used by different Authors.

Plates.	McCoy, 1847.	De Koninck, 1877.	Ratte, 1885–87.	Wachsmuth and Springer, 1886.	Bather, 1890.	Herein used, 1892.
1st Cycle...	Pelvis, or dorso-central plate.	La base.	Basals.	Under-basals	Infra-basals.	Infra-basals.
2nd Cycle...	First costals.	Sous-radiales	Sub-radials.	Basals	Basals.	Basals.
3rd Cycle	Interscapulars.	Premières pièces radiales.	Radials.	Radials.	Radials.	Radials.
	Scapulæ, or ray-bearing plates.	Pièces inter-radiales.	Inter-radials.			
	Intercostal.	Pièces anales (3.)	Anals.	Azygous plate.	Radianal.	Azygous plate.
	Second costal.	.. ..	.....	Anal piece, or subquadrangular anal plate.	Brachianal.	Anal.
	.....	.....	.....	Brachials.	Costals, or brachials.	Costals.

Messrs. Wachsmuth and Springer describe the azygous plate in *Tribrachiocrinus* as subquadrangular, or trapezoidal in outline, and the anal as subquadrangular; but in their diagramatic dissection[1] of the calyx, the latter is figured as pentagonal, and such in reality is the form of both. By Sir F. M'Coy the azygous plate, his intercostal, is correctly figured,[2] but

[1] Revision of the Palæocrinoidea, 1885, Pt. III (1), t. 6, f. 5.
[2] Ann. Mag. Nat. Hist. 1847, XX, t. 12, f. 2c.

the anal plate, his second costal, is represented as hexagonal; in the description it is said to be "obscurely hexagonal," but as previously stated the true outline is pentagonal. On the other hand, the late Prof. de Koninck represented[1] the outline of both these plates correctly.

Messrs. M'Coy, De Koninck, and Ratte described *Tribrachiocrinus* as possessing three arms only, and the two last named authors believed in the presence of inter-radial plates. Sir F. M'Coy says—"The arm-bearing plates or scapulæ, which are so generally five in the other genera, are only three in the present animal, forming a strong peculiarity, which it shares only with the genus *Triacrinus* of Count Münster."[2] Professor de Koninck, speaking of his "premières pièces radiales," remarks—"Elles ne sont qu'au nombre de trois, ce qui constitue une véritable anomalie dans la structure générale des Crinoïdes."[3] It naturally follows that, if *Tribrachiocrinus* possessed only three arms, we should expect to find only three radials bearing brachial plates for their support. On the other hand, according to the weighty opinion of Messrs. Wachsmuth and Springer,[4] "in three of the radials, the articulating faces form a straight horizontal line, and only these plates are opposed by regular brachials, the two others (those of the antero-lateral rays) being angular and higher at their distal ends. The general outline of the two last mentioned plates indicates that they are compound plates, each representing a radial and a bifurcating brachial, which probably became anchylosed." Messrs. Wachsmuth and Springer thus differ from the other authors named in regarding all the plates of the third cycle, except, of course, the anal plates, as radial to the exclusion of any inter-radial. At the same time, they suggest the presence of five instead of three arms, one attached to each of the radials with horizontal articulating faces, and one each to the two high and angular antero-lateral plates. Speaking of the two last-named plates, their words are[5]: "They evidently supported two arms, one at each side; while the three radials, with articulating brachials, apparently bear but a single arm like Cronyocrinus simplex, Trautschold."

A most careful examination of all available examples of *Tribrachiocrinus* has been made, including the specimen from which the cast was taken, and forwarded by Mr. Ratte to Messrs. Wachsmuth and Springer; and, although I must admit that there is every appearance of constricted distal ends to these

[1] Foss. Pal. Nouv. Galles du Sud, 1877, Pt. 3, p. 23.
[2] Ann. Mag. Nat. Hist., 1847, XX, p. 228.
[3] Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 162.
[4] Revision of the Palæocrinoidea, 1886, Pt. III (2), p. 250 (174).
[5] Revision of the Palæocrinoidea, 1886, Pt. III, p. 250 (174).

plates, still I am quite unable to find any trace of an articular surface such as these Authors suggest. It appears to me that Mr. Ratte more apropriately explained these plates in his "Second Note on *Tribrachiocrinus corrugatus*," wherein he remarked that the "Ankylosed brachials are very much reduced in size and thickness, and that if, according to Messrs. Waehsmuth and Springer, 'they evidently supported two arms, one on each side,' these arms were probably abortive, or at any rate very much reduced, or reduced next to nothing, as I do not see any sockets for them, nor any strength to support them."[1]

In *Tribrachiocrinus Clarkei* and *T. corrugatus*, the basal cup of the calyx is generally convex; in *T. ornatus* it seems to be somewhat flattened, whilst in *T. granulatus* it presents a semblance of concavity. The scar of attachment for the first stem-joint is small in all the species, but proportionately largest in *T. corrugatus*. In the form of the under-basals and basals there is a very close resemblance between all the species, except in outlines of the heptagonal, and its adjacent posterior hexagonal basals. These plates in *T. corrugatus* and *T. granulatus* are much more transversely-obliquely hexagonal than in *T. Clarkei*, and the suture between them is far shorter than between those of the type species. A great similarity exists in the form of all the radials, except that in *T. corrugatus* and *T. granulatus* the anterior radial is much more transversely pentagonal than in either *T. Clarkei* or *T. ornatus*. In both of these species the pentagon is decidedly deltoid-triangular.

The most important points of difference between the species, however, lie in the position and form of the azygous and anal plates. In *T. corrugatus*, and, apparently also in *T. granulatus*, were it not for the small truncated apex, the azygous plate would be quadrangular; but, in *T. Clarkei*, it is far less of this shape and more irregularly pentagonal in outline; and, besides, it is not thrust upwards between the anal and right posterior radial to anything like the same extent as in the species named. A similar difference is perceptible between the anal plates of the respective species. In *T. corrugatus*, the anal plate is roughly triangular, extending upwards a little beyond the azygous plate, and supporting with that plate, on their truncated upper edges, either a second anal, or the proximal plate of the ventral tube, which is thus interpolated between two of the radials.

[1] Proc. Linn. Soc. N. S. Wales for 1886 [1887], I (2), p. 1074.

In *T. Clarkei*, on the other hand, the triangular outline of the anal is lost, whilst the plate I have called the second anal assumes a comparatively large size, is in shape elongately-triangular, or somewhat lanceolate, and extends well downwards between the anal and right posterior radial, and lies horizontally against the truncated apex of the azygous plate.

As regards the sculpture, the plates appear to be plain in *T. Clarkei*, radiately-carinate in *T. ornatus*, vermicular-rugose in *T. corrugatus*, and granular in *T. granulatus*.

As to the systematic position of *Tribrachiocrinus*, it is satisfactory to find that McCoy's view, that the general disposition of the plates is most analogous to that of *Poteriocrinus*, is generally upheld by Messrs. Wachsmuth and Springer, who say, "the radials enclose the azygous plate proper and an anal piece, as in most of the *Poteriocrinidæ*." On the other hand, Mr. F. A. Bather in his classification[1] of the Inadunata-Fistulata entirely separates *Tribrachiocrinus* from *Poteriocrinus* and its allies, by placing it in a separate Family, the Decadocrinidæ, associating the genus with *Eupachycrinus*, *Cromyocrinus*, and *Agassizocrinus*, in the section Cromyocrinites. But, whilst acknowledging the force of the retention of the "three anal plates . . . . in the cup" as a strong character welding these genera together, I prefer to retain the old classification until Mr. Bather has elaborated his in a more ample form. By Prof. K. Zittel, *Tribrachiocrinus* is erroneously ascribed to Austin.

The genus, as regards its species, clearly dissolves itself into two well marked groups :—

A. Calyx highly asymmetrical as to its form, with a protuberant posterior side—

Tribrachyocrinus Clarkei, *McCoy*.
„ ornatus, *Eth. fil.*

B. Calyx more or less symmetrical as to its form, with the posterior side hardly at all protuberant—

Tribrachiocrinus corrugatus, *Ratte*.
„ granulatus, *Eth. fil.*

Type—Tribrachiocrinus Clarkei, McCoy.

Range—Permo-Carboniferous—New South Wales and Tasmania.

[1] Ann. Mag. Nat. Hist., 1890, V (6), p. 383.

Tribrachiocrinus Clarkei, *McCoy*.

Pl. XIII, Figs. 2–4; Pl. XIV, Fig. 3; Pl. XV, Figs. 6–8, and ? 5; Pl. XVII, Figs. 2–4.

Tribrachyocrinus *Clarkei*, McCoy, Ann. Mag. Nat. Hist., 1847, XX, p. 228, t. 12, f. 2.
,, *Clarkei*, McCoy, Proc. R. Soc. V. D. Land, 1851, I, p. 315, t. 12, f. 2.
,, *Clarkei*, De Koninck, Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 161, t. 6, f. 5, 5 *a-d*.
,, *Clarkei*, Etheridge, fil., Cat. Australian Foss., 1878, p. 41.
Tribrachiocrinus *Clarkei*, Wachsmuth and Springer, Revision of the Palæocrinoidea, 1886, Pt. III (2), p. 251 (175).
,, *Tasmanicus*, Johnston, Proc. R. Soc. Tas. for 1886 [1887], p. 231.

Sp. Char.—Calyx large, deeply cup-shaped, always produced asymmetrically towards the posterior side; plates thick, with strongly bevelled edges; greatest periphery at about one-third from the articular surfaces of the costals, or as near as possible along the basi-radial sutures; above this point the calyx is usually depressed or somewhat flattened. Infra-basal plates forming a shallow, asymmetrical, saucer-shaped cup. Heptagonal basal very large. Radials bearing costals, strongly shield-shaped, extended laterally along the articular margin into short angular processes. Azygous plate very large, always convex, and sometimes subangular in the middle line, according to the asymmetry of the calyx, its upper edge not extending to a point in line with the top ventral margin of the radials, but truncated and supporting the basal plate of the ventral; anal plate pentagonal, large, its ventral margin on a line with the ventral margin of the radials; second anal, or basal plate of the ventral tube, apparently quadrangular in shape, and much higher than broad. Costal plates large and transverse, with large articular facets. Columnar facet small; column unknown. Test unsculptured externally, but when decorticated[1] the plates present close concentric subimbricating ridges, which, towards the usually convex centres of the plates give place to undulating or festoon-shaped lines, resulting in a pentagonal or hexagonal star-shaped figure, according to the outline of the respective plates.

Obs.—I have included the asymmetrical form of the calyx as one of the specific characters from the fact that every specimen which has come under my notice is protruded towards the posterior side. One other species is similarly formed, but the remaining two are symmetrical in shape.

[1] By far the much more common condition.

In some instanees, the two pentagonal infra-basal plates are grooved by sulei passing from the columnar faeet to the middle of their respeetive infra-basio-basal sutures. This, at first sight, gives rise to a deeeptive subdivision of the infra-basal eup into five, instead of three plates, and is at times very marked. Sueh a subdivision is shown in one of Prof. de Koninek's figures.[1] Of the eonstruetion of the body on the ventral side above the radial plates little or nothing is known.

Sir F. MeCoy states that the plates seem in some eases to overlap eaeh other. This, I think, only arises from a partial bevelling of the edges, whieh many of them appear to possess.

Both MeCoy and De Koninek have mentioned a partial ornamentation of the ealyx plates. The former observes : "The surfaee is smooth, with the exception of a few irregular radiating plieæ at the margin of some of the plates." The latter Author's deseription is similar, but along the edges of some of the plates he observed a few irregular eoneentrie growth lines, instead of radiate markings. I have only met with two examples in whieh the ealeareous test was preserved, all others having been in the form of easts. The two in question have smooth plates, quite devoid of ornament of any kind, but in every instanee of an internal east, or with deeortieated plates, markings are present, and highly interesting and peculiar.

It will be remembered that Prof. de Koninek identified[2] Dana's anomalous genus *Pentadia* with the plates of the so-called *Cyathocrinus Koninckі*, Clarke, but an ineidental remark of Ratte's earries eqnal weight, and is almost as near the truth. Speaking of the relation of the plates in question to *Cyathocrinus*, he says: "But they might as well be separate plates of *Tribrachiocrinus*.[3]" Quite so! But, as a matter of faet, both Authors are eorreet, for I have no doubt that Dana's larger plate, known as *Pentadia corona*, is one of the large radials of *Phialocrinus Koninckі*, whilst the form of seulpture is common both to this and *Tribrachiocrinus Clarkei*.

First, as to the appearanee of this so-ealled ornament on internal easts. It is faintly exemplified in De Koninek's figures[4] of the present speeies, and more strongly so in our Pl. XIII, Figs. 2–4, both as regards the eoneentrie lines, and two or three radiating ridges; but in MeCoy's figures,[5] whieh represent ealiees with the test preserved, the plates are practieally plain.

[1] Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, t. 6, f. 5*d*.
[2] *Loc. cit.*, p. 165.
[3] Proc. Linn. Soc. N. S. Wales for 1884 [1885], IX, Pt. 4, p. 1159.
[4] Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, t. 6, f. 5,5 *a–d*.
[5] Ann. Mag. Nat. Hist., 1847, XX, t. 12, f. 2 *a* and *b*.

Let us now turn our attention to what I have termed decorticated, or, perhaps it should more correctly speaking be decalcified casts. In such instances, the major portion of the substance of the plate has gone, leaving the concentric and radiating lines behind, possibly from a different chemical composition to the remaining portion of the plates. Such casts are seen in our Pl. XV, Figs. 5–8, and are always accompanied by a hollow space above them representing the thickness of the removed plate substance. Through the exertions of Mr. B. G. Engelhardt, of the Public School, Jamberoo, I am able to demonstrate the presence of this ornament on the interior, rather than the exterior of *Tribrachiocrinus* plates. Pl. XXII, Fig. 6, represents the exterior of one of the basals of *T. Clarkei*, whilst Fig. 7 of the same plate shows the interior of this plate. The former is plain and without sculpture, the latter exhibits the described markings in an excellent manner. Again, Pl. XXII, Fig. 8, is the convex exterior of another plate, probably one of the radials[1] of the same species; whilst Pl. XXII, Fig. 9, is its interior, in which, if anything, the sculpture is more strongly marked than on the inner surface of the basal plate. In his earlier description of the Australian fossils, collected by the Wilkes' United States Exploring Expedition, Prof. Dana described the fossils called *Pentadia* as with "one side quite smooth, the other delicately and closely marked with parallel subcrenulate ridges, having the angles of a regular pentagon and concentric."[2] It may, therefore, I think, be accepted that this form of sculpture in *Tribrachiocrinus* is confined to internal casts and decorticated plates.

Pl. XV, Fig. 6, is the heptagonal basal, one of the angles of the heptagon being hid by the overhanging matrix; Fig. 7 of the same plate is one of the hexagonal basals; whilst Fig. 8 is the left non-arm-bearing anterior radial. As regards Fig. 5, I am somewhat in doubt, it may be either the left anterior basal of *T. Clarkei*, or the hexagonal anal-supporting basal of *Phialocrinus Koninckí*, and I am inclined to believe the latter from the strong radiating ridges, which coincides with the structure of Dana's *Pentadia corona*.

A hasty glance at the basal plate portrayed in Pl. XXII, Fig. 6 would lead one to regard it as the three infra-basals anchylosed, especially the appearance of the almost central depression, resembling that of the columnar scar. The figure of the interior (Pl. XXII, Fig. 7), however,

[1] The edges being broken, it is difficult to trace the exact form.
[2] American Journ. Sci., 1847, IV, p. 152.

dispels this impression, for, in addition to the sculpture being concentric to the margins of the plate, as a whole, and not to three parts individually, the planeness of the plate is opposed to the convexity of the ordinary dorsal cup.

The first or bottom plate of the ventral tube (Pl. XXII, Figs. 10 and 11) reposing on the top of the azygous plate, and wedged in between the posterior radial and anal plates is oblong in shape. Its position thus brings it within the ring of radials.

Tribrachiocrinus Clarkei, not only differs from *T. corrugatus*, Ratte, in size, sculpture of the plates, and its protuberant posterior end, but also in a more important structural point, the much greater ventral extension of the anal plate in the former species; that is to say, this plate is longer in *T. Clarkei* than it is in *T. corrugatus*, and the second anal correspondingly shorter. From *T. ornatus*, which resembles it in possessing an asymmetrical calyx, the present species is distinguished by the absence of the cristiform centre and radiating ridges on the various plates. From *T. granulatus*, by size, proportions of the calyx, and the symmetrical outline of the latter. Lastly, Mr. R. M. Johnston has described,[1] in words much too brief to be of specific value, a Crinoid from the Pachydomus beds of Darlington, Maria Island, Tasmania, as *Tribrachiocrinus tasmanicus*. From his remarks I take it to be no other than our *T. Clarkei*; in fact, Mr. Johnston appears to have been very doubtful about its specific value, for he remarks:—"The above species comes very close to, and perhaps may not be specifically distinct from, the smaller form with large perforation in tripartite pelvis described by Prof. M'Coy as *T. Clarkei*." The length, three inches, is quite equalled by our Pl. XIV., Fig. 3. The only peculiarity about Mr. Johnston's fossil seems to be the absence of the columnar perforation in the base of the calyx. The plates shown in Mr. Johnston's figures, besides the infra-basals, are the left posterior, heptagonal, and pentagonal basals.

Another point is worthy of consideration. I was at first inclined to believe that two species had been included within the illustrations of *T. Clarkei* now given. For instance, Pl. XIII, Fig. 2–4, represent one, the true species, corresponding with M'Coy and De Koninck's figures, whilst a larger form, illustrated by Pl. XIV, Fig. 3, and Pl. XVII, Fig. 2–4, differed from the preceding in its larger size. As, however, I am not able to detect any morphological difference, it appears better to allow them to remain under one

[1] Proc. R. Soc. Tas. for 1886 [1887], p. 233, Pl. (central figure).

name pending the discovery of more perfect specimens. Especially is this the case in the light of Pl. XVII, Fig. 2–4, wherein is exemplified the difference in outline produced by distortion due to pressure.

Locality[1] *and Horizon.*—Near the Reservoir, West Maitland (*H. D. Walsh*); and back of the College, Campbell's Hill, West Maitland, Co. Northumberland (*W. D. Filmer and J. Mitchell*); Singleton, Co. Northumberland (*S. Dodds*); Railway Cutting at Wollongong, Co. Camden (*C. Cullen*); Banks of the Minumurra River, near Jamberoo, Co. Camden (*B. G. Engelhardt*) :—**Upper Marine Series.** Nowra, Co. St. Vincent (*C. Cullen*) :—**Nowra Grit**[2], **Upper Marine Series.**

It will be seen from this that *Tribrachiocrinus Clarkei*, M'Coy, has not been met with out of the Upper Marine Series.

Tribrachiocrinus ornatus, *sp. nov.*

Pl. XIX.

Sp. Char.—Calyx large, cup-shaped, but asymmetrical, produced towards the posterior side; greatest periphery along the basi-radial sutures. Base flattened, gently concave inwards to the columnar facet. Ornament of the test very characteristic; each basal plate bears a central boss, from which four ridges radiate to the basi-radial sutures; the arm-carrying radial plates each bear two diverging ridges from a central point on the costo-articular margin to those points on the basi-radial sutures cut by the ridges of the basal plates, where the union of the two sets again produces prominent bosses.

Obs.—I regard the subject of Pl. XIX as specifically distinct from *Tribrachiocrinus Clarkei*, on account of the ornamented condition of the radial and basal plates. The condition of the fossil, a cast in the Nowra Grit, a matrix by no means lending itself well to the preservation of organic remains, does not permit of a more definite or extensive specific diagnosis than the above. As I have laid considerable stress on the non-appearance of sculpture externally on the plates of *T. Clarkei*, some explanation of the adoption of this character as a specific feature is necessary.

[1] By M'Coy *T. Clarkei* was recorded from Darlington, in soft grey shale (*Ann. Mag. Nat. Hist.*, 1847, XX, p. 229); and by De Koninck, from the Muree Quarries, Raymond Terrace. (*Foss. Pal. Nouv.-Galles du Sud, Pt.* 3, 1877, p. 163.

[2] The equivalent horizon in the Illawarra Coal-field, of the Muree Rock in the Hunter River Coal-field, from which *T. Clarkei* was recorded by Prof. L. G. de Koninck.

It will be observed, in the first place, that the ridges and tubercles are very plainly visible on the cast, notwithstanding the inhospitable matrix containing it. In the second place, the relative thickness of the test is exemplified by the vacuity between the cast and surrounding matrix. Within this vacuity, but impossible to be shown on the plate, are a number of projections from the bosses, showing that there were particularly strong portions of the plates, reaching and indenting the matrix around. These are visible, and, I take it, represent what would have been the external appearance of the calyx when perfect. Moreover, by turning the fossil about in various directions, so as to admit light between the cast and the matrix, the surface of the latter can be seen to be sufficiently undulating to correspond with the various inequalities visible on the surface of the former. These points admitted, it is impossible to unite the present fossil with that figured by Sir F. M'Coy, in which the test is preserved, or those of *T. Clarkei*, of a similar nature, given in the present plates.

This is the only species of *Tribrachiocrinus* in which any trace of the arms has been observed; but, from causes mentioned above, it is impossible to give details regarding them. The first costals appear to be succeeded by two others, followed by an axillary costal, which supports two arm-branches.

Locality and Horizon.—Nowra, Co. St. Vincent (*The late Rev. W. B. Clarke*) :—**Nowra Grit, Upper Marine Series.**

Tribrachiocrinus corrugatus, *Ratte.*

Pl. XVI, Figs. 5-10.

Tribrachiocrinus corrugatus, Ratte, Proc. Linn. Soc. N. S. Wales for 1884 [1885], IX, Pt. 4 p. 458, t. 68.

Tribrachiocrinus corrugatus, Wachsmuth and Springer, Revision of the Palæocrinoidea, 1885, Pt. III (1), t. 6, f. 5; *Ibid*, 1886, Pt. III, (2), p. 251 (175).

Tribrachiocrinus corrugatus, Ratte, Proc. Linn. Soc. N. S. Wales for 1886 [1887], I (2), Pt. 4, p. 1069.

Sp. char.—Calyx globose, of medium size, symmetrical; plates thick; greatest periphery at about the basi-radial suture; dorsal surface gently convex, and depressed around the columnar centre; ventral surface depressed; all sutures wide and deep; infra-basal plates forming a shallow, wide, saucer-like cup, concave in the centre, which is visible in a side view when the calyx is placed in its normal position. Pentagonal basal wide and large. Azygous plate flatter than in the type species, and relatively extending higher

in the calyx; anal plate much less transverse than in the type species, acutely pointed at its dorsi-lateral angle; second anal or basal plate of anal tube, small and quadrangular. Three arm-bearing costals large, their articular surfaces forming an isosceles triangle, with deeply excavated facets; radio-costal sutures wide and gaping. Disk plates small, polygonal, chiefly pentagonal and quadrangular. Columnar facet small; column unknown. Sculpture in the form of pits and anastomosing, tubercular, vermicular grooves on the infra-basal and basal plates; divaricating tubercular ridges on the radials; cast plain.

Obs.—Tribrachiocrinus corrugatus is an excellent and well defined species, and may be at once distinguished from the two preceding Crinoids by the sculpture of the plates; and, as regards shape, the nearly perfect symmetry of the calyx. I say nearly perfect, because there is the slightest possible tendency to bulge towards the posterior side, but hardly noticable unless closely looked for.

The late Mr. F. Ratte described the impressions of very small plates between the arm-plates, which he believed to be those of the vault. Wachsmuth and Springer, on the other hand, remark—"We seriously doubt if these plates . . . . are any such thing as vault-plates; we believe, if they are plates at all, that they formed a part of the disk, and as such were covering pieces." Mr. Ratte was unquestionably right in referring to the impressions in question as those of plates, but Messrs. Wachsmuth and Springer are probably correct in their interpretation.

The sculpture is seldom well preserved, the ridges dividing the vermicular grooves becoming worn; but when in a perfect condition are tubercular, as described by Mr. Ratte. A peculiarly marked pentagonal plate is represented in Pl. XIV, Fig. 7, probably a basal. The sculpture has the general appearance of that of the present species; but the ridges in the centre are distinctly radiate, and the surrounding pits circular and separate. It may possibly be a slight variation in the ornament of *T. corrugatus*, or even a distinct species.

The vermiculate-tubercular sculpture of the calyx of *T. corrugatus* is reproduced in a great measure in that of *Eupachycrinus magister*, Miller and Gurley,[1] from the Upper Coal Measures of Missouri. We are indebted to Mr. B. G. Engelhardt for the presentation of some fragmentary specimens from Jamberoo. Mr. Ratte's originals are in the Australian Museum.

[1] Journ. Cincinnati Soc. Nat. Hist., 1890, XIII, No. 1, t. 1, f. 1 and 2.

Locality and Horizon.—Jamberoo, Co. Camden *(C. Cullen and B. G. Engelhardt)*; Railway Cutting at Wollongong, Co. Camden *(C. Cullen)*; Northern bank of the Minumurra River, near Jamberoo, Co. Camden *(B. G. Engelhardt)* :—Upper Marine Series.

Tribrachiocrinus granulatus, *sp. nov.?*

Pl. XXII, Figs. 2 and 3.

Sp. Char.—Calyx depressed, and generally saucer-shaped, practically symmetrical; infra-basal cup flattened around its periphery, and concave inwards from just within the infra-basi-basal sutures, producing a wider and more open concavity than that in *T. corrugatus*. Suture between the heptagonal and hexagonal posterior basals shorter than that in *T. corrugatus*, with the result that the plates named and the azygous plate are transversely wider in comparison to the height of the more depressed calyx. Anal plate apparently pentagonal; second anal deltoid, and very prominent. Columnar facet large in comparison to that of *T. corrugatus*. Sculpture, on the cast of concentric lines parallel to the outlines of the plates, on the test of a minute compact granulation.

Obs.—This provisional species undeniably comes very near to *Tribrachiocrinus corrugatus*, but it appears to differ from it in three very marked features. In the first place, the calyx is much depressed in comparison with that of *T. corrugatus*, the only species with which it need be compared. The basal cup is much flatter and more depressed, and, above all, the brevity of the suture between the heptagonal and hexagonal basal plates is most marked. In addition to these, there is the external sculpture. In Pl. XXII, Fig. 3, is represented the internal cast of the calyx, with the concentric lines edging the various plates. Fig. 2 portrays the matrix and external mould of a part of this cast, on which the close, fine, granulation of the test is faintly preserved. Such an ornament can hardly be mistaken for the vermiculate-tubercular sculpture of *T. corrugatus*. If the external ornament in the latter species does not vary in a diminutive sense, and I have not any evidence of such a fact before me, but rather the opposite, the species must be separate. We owe a knowledge of this interesting fossil to the researches of Mr. B. G. Engelhardt, of the Public School, Jamberoo.

Locality and Horizon.—Banks of the Minumurra River, near Jamberoo, Co. Camden *(B. G. Engelhardt)* :—Upper Marine Series.

Genus—PHIALOCRINUS—*Trautschold*, 1879.[1]

Pentadia (pars), Dana, American Journ. Sc., 1879, IV, p. 152.
„ (pars), Dana, Wilkes' U.S. Explor. Exped., 1849, X (Geology), p. 712.
Phialocrinus, Trautschold (*non.* Eichwald), Kalkbrüche von Mjatschkowa, Pt. 3, 1879, p. 24[2].
Cyathocrinus, De Koninck (*non.* Miller), Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 26.
Phialocrinus, Zittel, Handb. Palæontologie, I Bd., I Abth., 1880, p. 360.
„ Wachsmuth and Springer, Revision of the Palæocrinoidea, Pt. I, 1879, p. 124; *Ibid*, Pt. III (2), 1886, p.p. 191 (115) and 253 (177).
„ Bather, Ann. Mag. Nat. Hist., 1890, V (6), p. 385.

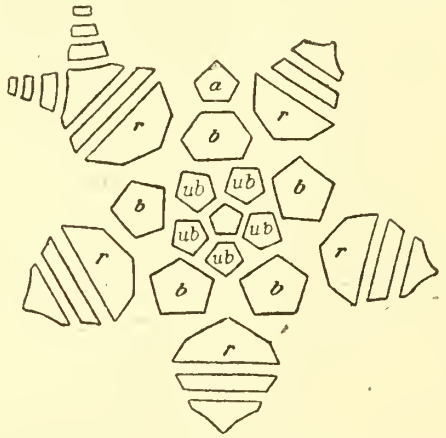

Fig. 4.

Gen. Chars.—Calyx, basin-shaped or globular, varying greatly in size, but attaining large proportions. Infra-basals five, pentagonal or quadrangular, the left anterior lateral usually the largest. Basal plates large, generally more or less arched, four pentagonal, the fifth or posterior hexagonal. Radial plates large, irregularly pentagonal, much wider than high, and their ventral margins sharply truncated; articular surfaces extending the whole length of the plates. Anal plate pentagonal or quadrangular, resting on the truncated ventral margin of the posterior basal, and interpolated between the right and left posterior radials, and thus not extending above the plane of the radials. Costals large, transversely elongated; the second or third axillary. Arms long, heavy, composed of strong, single pieces. Stem pentagonal, as a rule.

Obs.—The foregoing description is drawn up from the characters assigned to *Phialocrinus* by Mr. Trautschold, aided by the structure of the Australian species. The Author in question explained that Eichwald's genus

[1] *Non.* Eichwald, Lethæa Rossica, I, p. 579; *nec Philocrinus*, De Koninck, Quart. Journ. Geol. Soc., 1863, XIX, p. 4
Nouv. Mém. Soc. Imp. Nat. Moscou, 1879, XX (XIV), Livr. 1.

Phialocrinus, as originally proposed by the former, was established on very unsatisfactory and imperfect material, such as stem-joints, and is therefore quite inadmissable. In this step Trautschold is followed by Messrs. Wachsmuth and Springer, who regard[1] *Phialocrinus*, Trautschold, as a subgenus of *Graphiocrinus*, De Koninck[2]. Their remarks are as follows[3]:—"Closely related to *Graphiocrinus* are *Bursacrinus*, Meek and Worthen, and *Phialocrinus*, Trautschold. We can perceive slight structural differences by which the two might be distinguished from the first, but it can *only be a subgeneric division*, and it is somewhat questionable whether even this can be maintained as to *Phialocrinus*." And again[4]:—"The resemblance to *Graphiocrinus*, as already mentioned, is so close that we doubt whether the group *can be upheld even sub-generically*. So far as known, *Phialocrinus patens* differs from *Graphiocrinus*, as now revised, only in having two brachial pieces instead of one, and in the under-basals, which here project slightly beyond the column. The latter is unimportant, and a comparison will show that the two brachials combined have exactly the form of the single plate in *Graphiocrinus;* their division involves no structural change, but merely facilitates articulation."

It is, therefore, clear that *Phialocrinus* is clearly related to *Graphiocrinus*, but it appears to me that further consideration of the characters of the former, aided by the structure of certain Australian Crinoids, will enable a separation to be made. It may be remembered that the late Prof. de Koninck described a large Crinoid from our Permo-Carboniferous as *Cyathocrinus Koninckl*, Clarke.[5] This is not congeneric with *Cyathocrinus*, but, apparently, with another and much larger Crinoid, described later as *P. princeps*, and discovered since Prof. de Koninck wrote, thus forming a very natural group allied to *P. patens*, Trautschold. To these may, perhaps, be added a third, of which only the calyx is known, and, possibly, a fourth and somewhat abnormal form.

In *Graphiocrinus*, there is a single small anal plate situated half way between the radials and the costals.[6] In *Phialocrinus patens*, *Cyathocrinus Koninckl*, and in at least two of the new forms referred to above, the anal plate is wedged between two of the radials simply. In *Graphiocrinus*, this

[1] Revision of the Palæocrinoidea, Pt. I, 1879, p. 124.
[2] Rech. Crinoïdes Terr. Carb. Belgique, 1854, p. 114.
[3] *Loc. cit.*, p. 122.
[4] *Ibid*, p. 124.
[5] Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1887, p. 164, t. 6 f. 4.
Revision of the Palæocrinoidea, Pt. I, 1879, p. 122

anal plate rests either on the posterior basal, or is separate from it; but, in the species named, it is invariably perched on the top of the truncated apex of that plate. Again, in *Graphiocrinus*, whether on the posterior basal or separated from it, this anal plate extends above the plane of the radials; but, in the group of species, never; at any rate, not in the Australian. It further appears, from Trautschold's description, that there may be a few small supplementary plates.[1] I therefore propose to restore *Phialocrinus*, Trautschold, to the rank of a genus, a step which had the cordial approval of my late friend and co-writer, Dr. P. H. Carpenter, F.R.S., to whom I submitted casts and facts bearing on the generic relations of the Crinoids in question, at a time when much perplexed with their affinities. He was kind enough to favour me with his views on the matter in writing, and his permission was obtained to their insertion here.

Dr. Carpenter's remarks on the relation of *Phialocrinus* to *Graphiocrinus* are as follows :—

"In my opinion Messrs. Wachsmuth and Springer committed a great mistake when they redefined De Koninck's genus *Graphiocrinus*, and added a number of American species to it. No doubt they were right in supposing that *Graphiocrinus* has under-basals, concealed by the top stem-joint, but this has yet to be proved in *G. encrinoides*. In this, however, the type, and to my mind the *only* species of the genus, the five basals are all equal, the radials form a closed ring, and the anal plate rests upon the upper angles of two of them, separating the two costals (second, or axillary radials, *auctorum*). Wachsmuth and Springer refer the following species to *Graphiocrinus* :—

A.

Scaphiocrinus carbonarius.
,, rudis.
,, striatus.
,, simplex.
,, Wachsmuthi.

B.

Scaphiocrinus M'Adamsi.
,, spinobrachiatus.
,, tortuosus.

[1] Possibly the basal plates of the anal tube.

I know nothing about the anal side in the three species of Group B, but in all the five species of Group A, the anal plate enters the ring of radials and rests on a basal, just as in the case in *Cyathocrinus;* and I cannot comprehend how the Authors in question can have placed these species in the same genus with *Graphiocrinus encrinoides.* Their doing so is the more remarkable as they separate *Ceriocrinus* from *Erisocrinus* for a precisely similar difference.

"*Scaphiocrinus simplex,* one of the species in Group A, was Hall's type of *Scaphiocrinus,* and he distinguished it clearly enough from *Graphiocrinus,* expressly stating that the basal of the anal side 'is truncated above by the first anal plate.'[1] Waehsmuth and Springer, however, transferred this and similar species to *Graphiocrinus,* and enlarged the definition of the latter accordingly. This left *Scaphiocrinus* without a type, and so they made Hall's second species, *S. dichotomus,* the type of the genus, in which they have been followed by S. A. Miller and others.

"What, then, are we to do with *Scaphiocrinus simplex,* and its four or more allies? Strictly speaking, I suppose that Hall's name should be restored, and a new one found for *S. dichotomus* and the rest. This should, I think, be done, were it not that *S. simplex,* &c., all agree with Trautschold's *Phialocrinus patens,* in having the posterior basal truncated by the anal plate, which rests upon it, and forms part of the ring of radials, and I would therefore transfer *S. simplex,* and its four or more allies to *Phialocrinus,* making this character the generic difference between the latter and *Graphiocrinus. Scaphiocrinus M'Adamsi* and *S. tortuosus* (?) are described as having the basals unequal, and should probably be called *Phialocrinus* also. Of *Graphiocrinus longicirrifer,* W. and S.,[1] Waehsmuth and Springer themselves remark that the basal of the azygous side 'is considerably larger and heptagonal, supporting on its truncate upper face a large anal plate, which extends far beyond the top of the radials, and actually forms a part of the ventral tube.' How can they place this in the same genus with *G. encrinoides?* In fact, they seem to have entirely forgotten the structure of this, the type species of the genus! for they say of *Graphiocrinus*—'It has only an anal, and this is small and placed between the radials, resting upon the truncate upper side of the posterior basal.' And yet in the type species De Koninck pointed out how the anal plate is 'adjacente à quatre autres

[1] Illinois Geol. Survey Report, 1890, VIII, p. 193, t. 17, f. 14.

pièces qui l'enclavent et qui, à cet effet, ont chacune une partie de l'un de leur bords latéraux un peu echanerée.'[1] These are, of course, the first and second radials (*auctorum*), or radials and costals as we now call them.

"Again, in Wachsmuth and Springer's last paper on the perisomic plates of the Crinoids, they refer to the plate x as resting on the posterior basal, and supporting a 'quite capacious' ventral tube. This is not the case in the type of *Graphiocrinus*.

"I do not think that any importance, from a generic point of view, is to be attached to the extent to which the under-basals are visible beyond the stem articulation. Neither can anything be made of the fact that *Phialocrinus pateus* has two costals, while the American species resemble *Graphiocrinus* in having but one; for Hall says that there may be two in the anterior ray of *Graphiocrinus tortuosus*, which seems to have the anal structure of *Phialocrinus*, while Trautschold says that there may sometimes be only one costal in the latter genus.

"Miller and Gurley have recently described a new genus, *Esiocrinus*, which has a dicyclic and bowl-shaped calyx, with the posterior basal truncated for the reception of an anal plate and two costal plates. I cannot see in what respect this genus differs from Trautschold's *Phialocrinus*, though the authors think that 'probably a new family should be defined for its reception.'[2] They describe three species, each with two costals, which thus resemble the Russian rather than the other American species of the genus.

"*Bursacrinus*, M. and W., to which Wachsmuth and Springer have united *Synyphocrinus*, Trautschold, and I think rightly so, has the same arrangement on the anal side as *Phialocrinus*, but differs in having a more funnel-shaped cup, and more branching arms. The type species, *B. Wachsmuthi*, has six to eight distichals, but in *B. cornutus* there are but two. In either case, however, there are twenty arms, while *Phialocrinus*, so far as known, has but ten, and not always that, for there is no costal axillary on the anterior ray of *P. rudis*."

Phialocrinus, therefore, as now understood by us, is distinguished from *Graphiocrinus*, De Koninck, by the position of its anal plate, resting on the truncated ventral edge of the posterior basal, and thus entering the ring

[1] Rech. Crinoïdes Terr. Carb. Belgique, 1853, p. 116.
[2] Journ. Cincinnati Soc. Nat. Hist., 1890, XIII, p. 15.

of basals, without projecting above their ventral margin. In *Graphiocrinus*, on the contrary, the anal plate rests on the upper angles of two radials, or, according to De Koninck's figures,[1] it is placed between two rays, wedged between two radials and two costals. It is to be regretted that the utility of Messrs. Wachsmuth and Springer's grand work is sometimes marred by a contradictoriness of statement, which renders their actual views difficult of comprehension. In the revised generic diagnosis of *Graphiocrinus* given by them, they assign to the anal a somewhat analagous position—"either resting on the posterior basal or separated from it, but in either case extending above the plane of the radials." On the other hand, in a subsequent note on the genus,[2] they say, as quoted by Dr. P. H. Carpenter, that the anal is "small, and placed between the radials, resting on the truncated upper side of the posterior basal." I prefer, however, to accept their first definition, which practically causes *Graphiocrinus*, vobis, to differ from *Phialocrinus* as much as *Graphiocrinus*, De Koninck, does.

The separation of *Bursacrinus* from *Phialocrinus* has already been referred to by Dr. Carpenter.

Cromyocrinus, Trautschold, is another genus to which our Australian species of *Phialocrinus* bear a strong general resemblance. In the words of Messrs. Wachsmuth and Springer, when discussing the relations of the two first-named genera,[3]—"The species of both agree in the bowl-shaped, sometimes nearly globular form of the calyx, its comparatively very large size, its large and heavy plates, the massive and simple arms, and the exceedingly slender column"—but the structure of the anal side quite separates them from *Cromyocrinus*. The anals are three in number, the lower being the largest, and rests obliquely between the posterior basal and right radial. The second anal is placed between the first anal and left radial, and above the basal, whilst the third is much swollen, and only the lower half of it is included in the calyx.

Dr. Carpenter referred to the fact that *Æsiocrinus*, S. A. Miller, does not differ from *Phialocrinus*. Messrs. Miller and Gurley say of the latter that the calyx is bowl-shaped, with five infra basals (their basals), the basals (their sub-radials) large, four hexagonal and one heptagonal, the radials pentagonal, wider than high, and truncated their entire width, azygous plate

[1] Rech. Crinoïdes Terr. Carb. Belgique, 1853, p. 115.
[2] Revision of the Palæocrinoidea, 1886, Pt. III, No. 2, p. 252 (176).
[3] Ibid., 1879, Pt. I, p. 133.

resting on the truncated ventral edge of the heptagonal basal, and placed between two radials, whilst there are one or more costals in each ray, supporting strong arms of a single series of plates. Now, dismissing from consideration the proboscis, which they also describe in *Æsiocrinus*, it is manifest that this is, without exception, quite the structure of *Phialocrinus*. The basal plates are said by Miller and Gurley to be four hexagonal and one heptagonal, whilst those of *Phialocrinus* are now described as pentagonal and hexagonal respectively; at the same time it would be possible, without being absolutely incorrect, to describe these plates in the latter genus under similar terms—in this way—a glance at the figure of *Æsiocrinus Harei*, M and G.[1] will show that the four basal plates are rendered hexagonal by having their dorsal edges angled to fit into the emarginate ventral edges of every two and alternately conjoined infra-basals. Similarly with the dorsal edge of the heptagonal basal. As a matter of fact, on dissecting a worn example of *Phialocrinus Clarkei*, and separating the plates, I find that they also possess a tendency to a like outline, but when united *in situ* this is imperceptible. Under these circumstances therefore, it appears that there is little or no difference in the construction of the calices in *Phialocrinus* and *Æsiocrinus*.

It is satisfactory to find the views of the late Dr. P. H. Carpenter, of the affinities of *Phialocrinus* so much in accord with those of Mr. F. A. Bather, who places the genus with *Graphiocrinus*, *Ceriocrinus*, and *Bursacrinus* in a section of his family Decadocrinidæ, termed the Graphiocrinites. In the latter "the radianal is lost, but . . . . the brachianal remains in the limits of the dorsal cup." It may be explained that Mr. Bather's radianal is, as already pointed out, a radial "that has assumed anal functions"; whilst the brachianal is that plate termed in the present pages the anal.

Now a word as to the name *Pentadia*, Dana, lest any should contend for its adoption as the generic appellation of this group. I presume the giving a name to a single, or two or three Crinoid plates, is not sufficient warranty for its adoption in a generic sense. Such was the origin of *Pentadia*[3], but fortunately there is every reason to believe, as will be explained hereafter, that the plates of two distinct genera correspond to the structure of these *Pentadia* plates, and that in consequence it must be relegated without further discussion to the synonymic list.

[1] Journ. Cincinnati Soc. Nat. Hist., 1890, XIII, Pt. 1, t. 4., f. 1.
[2] Ann. Mag. Nat. Hist., 1890, V. (6), pp. 383 and 385.
[3] American Journ. Sci., 1845, IV., p. 152.

The form of the calyx is practically identical in *P. Koninckl* and *P. princeps*, but is much more saucer-shaped in *P. nodosus*, the two former being characterised by the very large size and massiveness of their plates.

The infra-basals are usually almost equal, but in *P. Koninckl* an inequality does certainly exist, the right antero-lateral plate being decidedly the larger. It is, however, more generally apparent in casts than in calices with the plates preserved. The projection of these plates cannot in any way be accepted as a generic distinction, as partly suggested by Wachsmuth and Springer, in the case of *Scaphiocrinus*. The infra-basals are retired from view in *P. Koninckl* and *P. nodosus*, but project in *P. princeps*.

The basal plates are very similar in the three species, five pentagonal and one hexagonal, and in the two larger forms are comparatively smooth and unornamented, but in *P. nodosus* are produced into large central nodes.

The radials are alike in *P. Koninckl* and *P. princeps*, the articular facets for the costals extending the whole width of the plates, so that the lower portions of the rays are of nearly the same width as the radials, a strong Neocrinoid character. The radials of *P. nodosus* are unknown to me.

The anal plate occupies precisely the same position in all three Australian species, perched on the top of the posterior basal, and interpolated between two radials, in a manner similar to that of the American species, *P. carbonarius*, *P. rudis*, &c. Such also is the case in *Æsiocrinus magnificus*. In the Australian Crinoids it is a quadrangular plate, but in the last named it is irregularly so.

The costals of *P. nodosus* are unknown, but in those with which we are acquainted some slight variation appears to exist in the number at the base of a ray. *Phialocrinus patens* has two costals in each ray, *P. Koninckl* has three, and so *P. princeps* appears to have. On the other hand, the American species proposed to be referred to the genus by the late Dr. P. H. Carpenter have but one, except *Æsiocrinus*, wherein there are "one or more brachials in each ray." The costal axillary is said to be absent in the anterior ray of *P. (Scaphiocrinus) rudis*. In *P. princeps* there certainly is a costal axillary, and the same exists in *P. Koninckl*, so that in this respect our Australian species seem to follow the Russian rather than the American.

The costals below the axillaries in the two last named species are of the same width as the radials, and therefore quite unlike many other Palæocrinoids, such as the Platycrinidæ and Cyathocrinidæ, in which these plates are very much less, and occupying a much smaller extent of the articular surface. There seem to be irregularities in the number of costals in each ray of *P. princeps*, which will be referred to in the specific description of that form.

The quadrangular plates figured by De Koninck,[1] resting on the ventral edge of the anal, are repeated in *Æsiocrinus*, for Miller and Gurley say that the anal in their genus "is followed by two plates that connect with the base of the proboscis."[2] In *P. princeps* the posterior side is not presented to view, and in *P. nodosus* it is not preserved above the anal plate. In neither of the Australian species is any trace of the proboscis visible.

The stem-facet is practically obliterated in *P. nodosus*, or at any rate represented by the merest tubercle; it is very small in *P. Koninckí*, but much larger in *P. princeps*. The stem in the last named was also moderately large (Pl. XVIII, Fig. 1); but of the stems of the other Australian forms, specifically, I am unable to afford any information. It is possible that the apparently stemless condition of *P. nodosus* may be akin to the obliteration of the stem-facet in *Agassizocrinus*. In *Comatula* the same thing occurs, and we again find a like occurrence in the Neocrinoid *Marsupites*.

As here defined, *Phialocrinus* is recognised as occurring in the Carboniferous areas of Russia and America, and in the Permo-Carboniferous of Eastern Australia, and probably India. Dr. William Waagen has described, from the middle division of the Productus Limestone of the Salt Range, in the Punjaub, a species as *Cyathocrinus goliathus*, which, from his remarks, in comparing his detached plates with *P. Koninckí*, certainly appear to place *C. goliathus* in congeneric relation with the Australian Crinoid. A second species was described by Waagen as *Cyathocrinus virgalensis*, but it is unimportant.

Type.—*Phialocrinus patens*, Trautschold.

Australian Type.—*Phialocrinus Koninckí*, Clarke, sp.

Range.—Carboniferous and Permo-Carboniferous.

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[1] Foss. Pal. Nouv.-Galles du Sud, 1877, Part 3, t. 6, f. 4.
[2] Journ. Cincinnati Soc. Nat. Hist., 1890, XIII, No. 1, p. 14.

Phialocrinus Koninckı, *Clarke, sp.*

Pl. XVI, Figs. 1–4.

Pentadia spatangus, Dana, American Journ. Sci., 1845, IV, p. 152.

Pentadia corona, Dana, Wilkes' U. S. Explor. Exped., 1849, X (Geology), p. 713, t. 10, f. 10, 10*a* (non figs. 11 and 12).

Cyathocrinus Koninckı, Clarke, in De Koninck's Foss. Pal Nouv.-Galles du Sud, 1877, Pt. 3, p. 164, t. 6, f. 4–4*b*.

Cyathocrinus Koninckı, Etheridge, fil., Cat. Australian Foss., 1878, p. 40.

Pentadia corona (pars), Etheridge, fil., *Loc. cit.*, p. 40.

Sp. Char.—Calyx very large, massive, globular and globose; greatest periphery more or less along the basi-radial sutures; all sutures deep and well marked; plates of considerable thickness, more or less convex. Infra-basal plates quadrangular, slightly unequal in size, forming an inverted or reversed cup, on the outer margin of which the calyx rests when placed in its natural position. Basal plates large and massive, wider than high, irregularly convex, their relative sizes, as compared with the infra-basals being very disproportionate; four pentagonal, but the posterior basal hexagonal. Radial plates transversely elongated, pentagonal, articular surface large, with the internal edges sigmoidal. First and second costal plates broad and tabular; third costals axillary, and much higher than the others. Anal plates flattened, quadrangular, wider than high; supplementary anal plates (? or proximal plates of the proboscis) two, side by side, resting on the horizontal ventral edge of the anal plate. Columnar facet small; column unknown. Sculpture, apparently none, but highly weathered or decorticated specimens with lines concentric to the plate outlines, supplemented with radiating ridges.

Obs.—This fine species is second only in size to the still larger *Phialocrinus princeps*, described later on. Prof. de Koninck's figure represents a specimen three and a-half inches wide by two and a-quarter inches high, whilst the largest of our examples (Pl. XVI, Fig. 2) is but little less.

Prof. de Koninck referred *P. Koninckı*, Clarke, to *Cyathocrinus*, and it no doubt presents a resemblance to many species of that genus; but although the anal plate rests directly on the truncated apex of the posterior basal, as is also the case in *Cyathocrinus*, yet the width of the articular facets

of the radial plates forbids a reference to that genus. In *Cyathocrinus* the articular facets seldom occupy more than one-half the width of the plates, and sometimes less. Furthermore, in some of the American species, now placed in *Phialocrinus*, and referred to *Graphiocrinus* by Wachsmuth and Springer, the first two, or proximal plates of the "ventral tube," or "proboseis," rest on the anal plate, as they do in the present case. The impressions of these proximal plates are distinctly visible in the side view of De Koninck's large figure,[1] and are referred to by him as anals; but so far I have only been able to distinguish one of these in the specimens before me.

Phialocrinus Koninckl is only known to me in the form of internal casts. In this condition, the base on which the calyx would otherwise rest (Pl. XVI, Fig. 1) is represented by a depression of variable depth and width, but usually of considerable proportions, in which the five infra-basals would lie. This marked dorsal hollow is very characteristic of the species, and all specimens from the chief locality yielding *P. Koninckl*, Nowra, in the Shoalhaven District, exhibit it. The calyx, in this condition, when placed in its natural position rests as near as possible on the inter-basi-infra-basal sutures, and, in consequence, the infra-basal plates are invisible in a side view. It not infrequently happens that specimens from the Nowra Grit are more or less pressed out of shape, a fact which should always be taken into consideration when comparing them with others from different localities.

I was for some time doubtful as to the relations of *Phialocrinus Koninckl* to *P. princeps*, whether or no the basal hollow of the latter, when in the condition of casts, would be entirely filled by the plates *in situ*. I have, however, come to the conclusion that such would not be the case, and that the two forms are quite distinct, separated by the combined form of their respective infra-basal plates. With neither of the other species need *P. Koninckl* be compared.

Prof. de Koninck suggested the identity of the bodies described by Prof. J. D. Dana in the Geological Report of the "United States Exploring Expedition," under Commodore Charles Wilkes, U.S.N., as *Pentadia corona*[2], with the basal plates (his sub-radials) of the present species. De Koninck remarked[3]:—"In carefully examining each sub-radial impression, one can easily see five folds, faintly indicated, springing from a common central,

[1] Foss. Pal. Nouv.-Galles du Sud. Pt. 3, 1877, t. 6, f. 4.
[2] Wilkes' U.S. Explor. Exped., 1849, X (Geology), p. 713.
[3] Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 165.

well defined point, and directed perpendicularly towards the middle of each of the five sides. This arrangement presents an unmistakeable analogy to the fossil figured and described by Dana under the name of *Pentadia corona*. Indeed, this fossil corresponds so well in form and size with the sub-radials of our *Cyathocrinus*, that I am led to believe it may be nothing more than one of these pieces. In that case, these sub-radials would be ornamented not only with the radiating costæ that I have just mentioned, but also with concentric granulated striæ parallel to the margins." De Koninck is, no doubt, correct in describing such radiating folds and concentric granular ridges on the basal plates of *P. Koninckí*, for such are visible in his figures, and more satisfactorily on one of our own (Pl. XVI, Fig. 2). But, as regards the identity of Dana's *Pentadia* plates wholly with the basals of the present species, this, I think, can only be admitted in part, for it has already been shown that some of the plates of *Tribrachiocrinus Clarkei*, when in a particular state of preservation, also display a similar arrangement of concentric lines and radiating ridges. Such a reference was evidently conceived by Prof. Dana himself[1] when describing the several plates under the united name of *Pentadia corona*.

The figure of *P. corona*[2] given by Dana bears about six folds passing from the node-like centre to the middle of the plate margins, not to the angles. To the latter are other subsidiary ridges, rather than folds, thus dividing the surfaces of the plate into twelve triangular spaces. The object is further crossed concentrically by a series of semi-imbricating laminæ, becoming coarser and more distant from one another towards the centre. It must be borne in mind that so perfect an example as figured by Dana is seldom seen, but a glance at our Pl. XVI, Fig. 2, and the upper figure of De Koninck's illustration[3] exhibit the points referred to sufficiently well to warrant the assumption that his *Pentadia spatangus*[4], as it was originally termed, is identical with the basals of *P. Koninckí*. At the same time, I must confess that, should the two Crinoids *P. Koninckí* and *Tribrachiocrinus Clarkei* be found together in a disintegrated form, it would require a critical study of the outlines of the plates to differentiate between the respective species in that condition. The reference of Pl. XV, Figs. 6–8, and Pl. XXII, Figs. 6–9, to the latter species is based on the fact that more perfect remains of *T. Clarkei* occur in company with them at the same locality.

[1] Wilkes' U.S. Explor. Exped., 1849, X (Geology), Atlas, Expl. Pl. 10, f. 10.
[2] *Loc. cit.* t. 10, f. 10, 10*a*.
[3] Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, t. 6, f. 4.
[4] American Journ. Sci., 1847, IV., p. 152; Wilkes' U.S. Explor. Exped., 1849, X (Geology), Atlas, t. 10, f. 10, 10*a*.

With regard to the identity of *Pentadia reniformis* and *P. trigona*[1], I am not at present able to offer any suggestion.

Another marked peculiarity in the casts of *P. Koninckı* is the line of small nodes along the basi-radial and inter-basal sutures (Pl. XVI, Fig. 2), also to some extent visible in De Koninck's figures. Do these represent vacuities or depressions along the articular margins of the plates, in which were lodged fibre-bundles for the firmer union of the plates, otherwise loosely articulated ?

In *P. patens*, Trautschold, each radial is succeeded by two costals, the second being axillary. In the present species, however, judging from the cast, there appears to be three, with the third axillary.

The fine example represented in Pl. XVI, Fig. 1, was collected by Mr. E. F. Pittman, Government Geologist.

Locality and Horizon.—Nowra, Co. St. Vincent (*Messrs. E. F. Pittman and C. Cullen*) :—Nowra Grit, Upper Marine Series.[2]

Phialocrinus princeps, *sp. nov.*

Pl. XVII, Fig. 1 ; Pl. XVIII, Fig. 1 ; Pl. XXII, Fig. 5.

Sp. Char.—Calyx very large, globular-globose, with a protuberant base, on which the calyx rests when placed in its normal position ; greatest periphery about the basi-radial sutures ; sutures all deeply marked ; plates very thick. Infra-basals forming an expanded shallow cup visible in a side view, the left antero-lateral the larger. Radial plates very large, their convexity so slight that the surfaces present a more or less flattened appearance. Costals strong and massive, the radio-costal sutures gaping ; in the anterior ray the first costal transversely triangular-quadrate, second transversely tabular (? axillary), succeeded by three sub-alternate more or less triangular smaller pieces (? distichals), the third of which is axillary ; succeeding pieces (? palmars) thick, alternate, and triangular. Column of large joints. Sculpture none.

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[1] *Loc. cit.* p. 152 ; *Ibid*, t. 10, f. 11 and 12.

[2] Prof. L. G. de Koninck gives as the original locality for this species, Osterley, Hunter River (*Foss. Pal. Nouv.-Galles du Sud*, Pt. 3, 1877, p. 166). Osterley is three miles from Hinton.

Obs.—The present noble species is probably one of the largest, if not the largest, of the Palæocrinoidea known, equalling if not exceeding the large *Barycrini*, of the American Carboniferous Limestone. The calyx is four and a-half inches in diameter, and about three and a-half inches in height. The anal or posterior side has not been observed, as it is broken away in all other examples other than that of the subject of Plate XVIII, Fig. 1, where it is hopelessly imbedded in an exceedingly hard silicious matrix.

It differs essentially from *P. Koninckı* in the possession of protuberant infra-basals, and in consequence, when the calyx is normally placed, they are visible laterally.

The stem-joints in this species are fairly large, measuring quite three-quarters of an inch in diameter.

The form of the two anterior basals is precisely similar to that of those of *P. Koninckı*, and in the large figured specimen (Pl. XVIII, Fig. 1) the breadth of the two plates is equal to that of an entire calyx of an ordinary sized individual of the species named. A separate plate is represented in Pl. XXII, Fig. 5, seen from the interior, with the concentric structure-sculpture seen both superficially and in section.

In all the three exposed rays in *P. Koninckı* there are two arms to the ray. There are two on the left hand ray of *P. princeps* (Pl. XVIII, Fig. 1) but the right-hand ray is so defective that the number is doubtful. On the other hand two are definitely present on the central ray (anterior), and perhaps a third. The anterior radial is followed by two costals, the first triangularly quadrate, the second transversely elongate, or tabular. Whether or no this plate is axillary I am undecided, but the three next pieces are triangular and subalternate. If the second costal is axillary, these plates will I presume be termed distichals; the third of them is certainly axillary, and the pieces beyond will, with the above reading, become palmars. At the same time, the second of these triangular plates (distichals) has the appearance of being axillary, although too much stress must not be laid on this point, from the state of preservation, but it is from this cause that I have above suggested the presence of a third arm.

The figured example is from the Collection of the Maitland Scientific Society, and was obtained during an excursion of that body to Mount Vincent

by Messrs. J. Waterhouse, M.A., and G. Steward, under considerable difficulties, and the Department is indebted to the Council of the Society for permission to use the specimen for illustrative purposes.

Locality and Horizon.—Bow-wow Creek, Mount Vincent, near East Maitland, Co. Northumberland (*Messrs. J. Waterhouse, M.A.*, and *G. Steward*—Collection Maitland Scientific Society):—**Muree Rock, Upper Marine Series.**

Phialocrinus ? nodosus, *sp. nov.*

Pl. XIV, Figs 4 and 5.

Sp. Char.—Calyx very depressed saucer-shaped; basal concavity wide and open, wholly containing the infra-basals, and a portion of the basal plates. Infra-basals relatively large. Basals proportionately very large, thick, strong, and arched, each bearing centrally a blunt, prominent boss, on which the calyx rests when placed in its normal position; posterior basal less convex than the others. Radial plates not preserved, but their impressions convey the idea of low, transversely elongated, thick plates, and the anal on the truncated surface of the posterior basal similar in character. Sculpture (of the cast) consisting of concentric lines parallel to the margins of each plate surrounding the central boss. Stem-facet apparently absent.

Obs.—The number, form, and arrangement of the infra-basals and basals, and almost certainly that of the radials also, render this Crinoid congeneric with *P. Koninckii*, and *P. princeps*. The low height of the calyx, the wide, open basal concavity, and the central elevations of the basal plates are features which at once tend to separate *P. nodus* from the foregoing species. It rests on the apices of the basal nodes after the manner of a tripod on its three legs.

The basi-radial sutures are so much curved that a quadrangular aspect is given to the basals, but the articular margins are all sufficiently angular to give a pentagonal outline to the plates.

The specimen is a decorticated cast, and consists of infra-basals and basals, with the wide, low, articular surfaces of thick radials, and the anal plate. A cast was submitted to the late Dr. P. H. Carpenter, who agreed with the Writer as to its affinity with *P. Koninckii* and *P. princeps*.

There is no scar of a stem-facet, the apical or inner ends of the infra-basals converging only to an initial point. If a column existed, it must have been excessively small; the probability is, however, that it was lost at an early stage of the Crinoid's existence, the scar closing over as in *Comatula*, and *Agassizocrinus*. The question arises, is it not one of those *Encrinus*-like forms which mark the transition from Palæo- to Neocrinoids.

Locality and Horizon.—Copper Point, Co. St. Vincent (*R. Barnes*—Collection Australian Museum) :—Upper Marine Series.

Phialocrinus ? Stephensi, *sp. nov.*

Pl. XX, Figs. 1–5.

Sp. Chars. (Cast).—Body pyramido-conical, height two and a quarter inches, diameter two and a half inches. Calyx depressed, low, wide, greatest periphery along the basi-radial sutures; dorsal surface very concave, deeply hollowed out, and generally resembling the base of a wine-bottle. Infra-basal plates confined to the basal concavity, and entirely hidden from view when the calyx is placed in its normal position, unequal in size, quadrangular. Basal plates in two planes, much bent along a circumferential line at about one-third from the infra-basi inter-basal sutures, so that their dorsal margins are hidden in the basal concavity; four pentagonal, the anal or posterior hexagonal; inter-basal sutures prominent, each rising into a blunt tubercle, where it cuts the edge of the basal concavity. Radial plates transversely elongated, pentagonal, wider than high, the lateral portions convex, the middle lines concave and inwardly pressed, especially at their dorsal apices; basi-radial sutures prominent, produced into a prominent oblique crest, converging towards one another in pairs; articular ventral margins long, and rather concave. First costals (?) large, transversely elongated, flat and tabular; second and third costals (?) transverse also, but larger, and apparently anchylosed together, and the latter axillary. Anal plate quadrangular, supporting smaller proboscis plates. Column unknown, probably absent, judging from the minute size of the scar of the first stem-joint.

Obs.—The above description has been drawn up from an internal cast, and it is only after some hesitation that I have placed it congenerically with *Phialocrinus Koninckii*, and *P. princeps*. The diagnosis is therefore purposely

enlarged beyond strict specific limits. The low calyx, deep ventral concavity, into which the basal plates fairly enter, and the diminished scar of the first stem-joint, recall the characters of *P. nodosus*, but our want of knowledge of the latter above the basi-radial sutures prevents further comparison.

The most interesting point in the structure of *P. Stephensi* is the relatively small calyx as compared with the preponderating mass composed of what I regard, for the want of a better explanation, as the anchylosed first, second, and third costals. A glance at Pl. XX, Figs. 1–3, will show that the infra-basals, basals, and radials compose the saucer-shaped calyx, as in *P. nodus*; whilst in Fig. 3, is visible the anal plate reposing on the truncated basal, as in *P. Koninckı* and *P. nodosus*. So far the structure seems to be simple enough, and corresponds with its fellow species, but above the radio-costal sutures we are confronted with the heavy, and apparently anchylosed mass seen in Pl. XX, Figs. 1–5.

On the radials are placed five more or less tabular plates, the two posterior separated by the impressions of the plates of the ventral tube, and which, I presume, represent the five first costals, with well marked vacuities representing the articular surfaces, between them and the radials, and again between them and the plates above. The latter seem to be the impressions of the second and third costals, if the prominent terrace-like ridge running round the specimen represents the sutures between the plates otherwise anchylosed together. This explanation is advanced tentatively, for at present I see no other reading of the structure of this specimen. The long radio-costal articular surfaces are similar to those of *P. Koninckı*, and to the exposed rays of *P. princeps*. The inter-costal articulation between the first and second is also similar.

The question that naturally presents itself to one's mind is—Do the lateral union and consolidation of the costals—presuming the pieces to be so united in the perfect organism, similar to this cast—infer generic distinction, the other portions of the calicicular structure being on the same plan? It appears to me that the answer to this question depends on the classificatory value placed on the structure of the arm-pieces in a Crinoid generally. Amongst the best characters assigned by Messrs. Wachsmuth and Springer[1] for generic separation, the construction of the arms is placed last, and may,

[1] Revision of the Palæocrinoidea, Pt. I, 1879, p. 24.

therefore, be looked upon as of the least importance. Mr. Bather also appears to be of the same opinion, for he says :—"Arm characters in general may, however, be used as a check on other methods of classification ; they enable us to correct possible errors in phylogeny."[1] Under these circumstances, unless other more important differences can be pointed out by those having a closer knowledge of Crinoid structure than myself, *P. Stephensi* must remain associated with *P. Koninckl* and *P. princeps*.

In the description of *Phialocrinus Koninckl*, reference was made to the peculiar broken appearance in the cast of some of the sutures, taking the form of distinctly separated pimplets or small nodes. Similarly, in *P. Stephensi* are the elongated prominences along the basi-radial sutures. These crests could hardly exist in their present position without some outward sign of their presence on the plates proper, and it is, therefore, assumed that they did so, and moreover were not of precisely the same nature as those in *P. Koninckl*.

I was, in the first instance, indebted to the late Prof. W. H. Stephens, M.A , after whom the species is named, for its loan. It was subsequently presented to the Mining and Geological Museum by the Executors of the late Mr. David Berry, of Cooloomgatta, who obtained it from the late Mr. William Berry, the finder.

Locality and Horizon.—Nowra, Co. St. Vincent (*The late W. Berry*) :—
Nowra Grit, Upper Marine Series.

CRINOIDEA INCERTÆ SEDIS.

Column.

XIII, Figs. 5 and 6.

Obs.—Portion of a large column, consisting of close set stem-joints, twelve in the space of one inch vertical, and with a diameter of one inch. These figures illustrate a common form of column found extensively throughout the Upper Marine Series of the Shoalhaven District.

Locality and Horizon.—Shoalhaven District (*Pres. J. Maclean*) :—
Upper Marine Series.

[1] Ann. Mag. Nat. Hist. 1890, V (6), p. 376.

Actinocrinus ?

Pl. XIV, Fig. 6; Pl. XVI, Fig. 11.

Obs.—An impression of a plate, perhaps a primary radial, ornamented with diverging ridges or costæ. It appears to represent an undescribed Australian Crinoid, as none of the calyx plates, so far discovered, exhibit a similar sculpture, with the exception of that figured in Pl. XVI, Fig. 11.

Locality and Horizon.—Nowra, Co. St. Vincent (*C. Cullen*) :—**Nowra Grit, Upper Marine Series.**

Tribrachiocrinus ?

Pl. XIV, Fig. 7.

Obs.—Impressions of a basal-plate of a form probably allied, from the style of the ornamenting tubercles, to *T. corrugatus*. The centre of the plate bears radiating costæ, bordered by two rows of coarse granules or nodes. The radii are to some extent elongately club-shaped.

Locality and Horizon.—Shoalhaven Heads, Co. Camden, (*C. Cullen*) :—**Upper Marine Series.**

Column.

Pl. XVII, Fig. 5.

Obs.—Portion of a column about four and a-half inches long with parts of three verticils of cirri still attached, from three-quarters to one inch apart. The cirri would appear to have been of some length. Every fourth stem-joint seems to be somewhat larger than the intermediate ones.

Locality and Horizon.—Gerringong, Co. Camden, (*C. Cullen*) :—**Upper Marine Series.**

Column.

Pl. XVIII, Fig. 2.

Obs.—Portion of a column, with a well marked nodal-joint, supporting bases of three cirri, which are circular. The ordinary stem-joints are one-sixth of an inch high; the nodal-joints one-fourth, and the latter also have a wavy outline. The internodal-joints are plain and all similar.

Locality and Horizon.—Flat Rocks Creek, near Nowra, Co. St. Vincent (*C. Cullen*) :—**Upper Marine Series.**

Column.

Pl. XVIII, Fig. 4.

Obs.—Portion of a smaller column, also with a nodal-joint, which has a rounded periphery, and is larger and projects beyond the internodal-joints. Every fourth joint amongst the latter is, as in Pl. XVII, Fig. 5, larger than the others, and slightly rounded, the internodal being flat.

Locality and Horizon.—Ellalong, Mt. Vincent, Co. Northumberland (*C. Cullen*) :—Muree Rock, Upper Marine Series.

Radial Plate.

Pl. XX, Fig. 9.

Obs.—An impression of a thick radial with a large, clearly marked articular margin, and bearing diverging lines of coarse granules or small tubercles, and a medium line extending down the centre of the plate. Probably *Tribrachiocrinus*.

Locality and Horizon.—Mt. Terry, Jamberoo, Co. Camden (*B. G. Engelhardt*, Collection Australian Museum) :—Upper Marine Series.

ENLARGED STEMS.

Obs.—Crinoid stems in the Carboniferous of other countries are frequently found enlarged and of irregular growth, arising from the action of parasitic organisms within and without the stems. A full description of these will be found in the paper quoted below.[1] Irregularities of this nature are usually accompanied by a depression of the stem surface, or a hole, leading to the interior of the latter. Instances of this nature are correspondingly rare in our Permo-Carboniferous, one only having come under notice. (Pl. XVIII, Fig. 3.)

It was shown by the late Mr. J. Rofe[2] that one form of enlargement was caused by the work of a parisitic coral, *Monilopora crassa*, M'Coy, sp., and other methods of distortion have been described by the Writer, through the

[1] R. Etheridge, jun. Observations on the Swollen Condition of Carboniferous Crinoid Stems. *Proc. Nat. Hist. Soc. Glasgow*, 1879.

[2] Note on the Cause and Nature of the Enlargement of some Crinoidal Columns. *Geol. Mag.*, 1869, VI, p. 351.

agency of some encrusting Corals, Polyzoa, and a peculiar species of Productidæ called *Etheridgella complectens*, mihi, sp. The enlargement does not generally appear to be effected so much by a perforation of and burrowing into the stems, as by irritation set up by the foreign organism, and a consequent effort on the part of the Crinoid to secrete calcareous matter and invest the pest.

A similar enlargement and irregularity of growth is also very marked in stems of the Jurassic genera *Apiocrinus*, and *Millericrinus*. The former was also studied by Mr. Rofe, and both have been by Dr. L. von Graff,[1] who ascribes themischief to *Myzostoma*, a genus of Anarthropoda. No doubt some of the appearances produced in Carboniferous Crinoids are also due to the action of a Myzostomid, for I have figured[2] a column in which the occupant of the burrow appeared to be an Annelid.

Dr. P. H. Carpenter says[3] that the external parasites of living Crinoids are many and various, such as "small bivalves, Sertularian Hydroids, Polyzoa, tube-worms, and corals," but chief amongst them is *Myzostoma*, Graff. The latter attaches itself to the stalk, disc, and arms, usually causing an abnormal growth of the calcareous tissue so as to form a cyst. He adds, "I have never met with any distortion of the stem [of a living Crinoid] which could be considered as resulting from the action of a parasite, and it is therefore curious that abnormal growths in the stems of fossil Crinoids should have attracted the attention of so many Palæontologists."

The portion of column represented in Pl. XVIII, Fig. 3, is unfortunately broken short off about midway on the swelling, but not without showing that the enlargement was accompanied by the usual depression of the surface, and apparent perforation. The former breaks the continuity of six ossicles of the column from its fracture upwards, but this is possibly only half the original depression. The swelling or enlargement is above the latter, the column at its upper end having a diameter of three-eighths of an inch, whilst at the most inflated part it is five-eighths. This specimen was obtained by Mr. C. Cullen at Ellalong, near East Maitland. A second swollen stem has been presented by the Chief Surveyor, Mr. Twynam, from the parish of St. Aubin, Rouchel Brook District. A section has distinctly revealed the cavity, which seems to have given the penetrating

[1] Ueber einige Deformitäten an fossilen Crinoiden. *Palaeontographica*, 1885, XXXI, p. 185, t. 16.
[2] *Loc. cit.*, t. 4, f. 18 and 19.
[3] Challenger Report, Zool. XII, 1884. Report on the Crinoidea, pp. 133 and 135.

agent access to the central canal. The substance of this has been removed, and on subsequent pressure being applied the stem shell has caved in more or less in a vertical direction.

Class—CYSTOIDEA.

Obs.—Evidence is entirely lacking of the presence of this Class in the Carboniferous and Permo-Carboniferous rocks, either of New South Wales, Queensland, or Western Australia.

Class—BLASTOIDEA.

Obs.—Blastoids have not been met with either in New South Wales or Western Australia, but the Gympie Series of Queensland has yielded three genera, comprising three species. The descriptions of these have so far not been published, but will appear in the work on "The Geology and Palæontology of Queensland and New Guinea," by Mr. R. L. Jack and the Writer.

The genus *Mesoblastus* has been provisionally used as the receptacle for a rather aberrant species described as *M. ? australis*, Eth. fil;[1] but it is pointed out that a new genus may be required for its reception. A fragmentary specimen, but nevertheless quite distinct from either of the other Australian Blastoids, is described as *Granatocrinus ? Wachsmuthi*, Eth. fil.,[2] and, lastly, a peculiar form fulfilling most of the characters of *Tricœlocrinus*, is figured as *T. ? Carpenteri*.[3]

Sub-Kingdom—ANNULOSA.

Section—*Anarthropoda.*

Class—ANNELIDA.

Obs.—I am not aware that the shelly tubes of the Tubicola, or the horny jaws of the Errantia have been, so far, met with in our Permo-Carboniferous, although the latter are known from the Upper Silurian of New South Wales,[4] having been collected, with a large number of other interesting organisms, at Bowning by Mr. John Mitchell, of Narellan Public School.

[1] *Loc. cit.*, t. 44, f. 2.
[2] *Loc. cit.*, t. 7, f. 10.
[3] *Loc. cit.*, t. 44, f. 3.
[4] R. Etheridge, jun. Geol. Mag., 1890, VII (3), p. 337

From Western Australia, on the other hand, Dr. G. J. Hinde has recorded[1] a *Spirorbis* from the rocks of the Gascoyne River, believing it to be referable to the Devonian *S. omphalodes*, Goldf. It does not appear to me, however, that the Devonian age of these rocks is yet sufficiently well proven.

Amongst the later collections made by Mr. Cullen were a number of Encrinite stems from near Mount Vincent, on which a few microzoa were seen adhering. Amongst them was a small loosely coiled *Serpula*, hereinafter described as *S. testatrix*.

A few Carboniferous fossils have lately been presented to the Mining and Geological Museum by Mr. Connelly from twenty-five miles west of Coerdawandy, Yaltra Mountains, Gascoigne River District, Western Australia, and amongst them, reposing on a small Crinoid stem, is a pretty little *Spirorbis*, after the type of *S. ambiguus*, Fleming,[2] from which I am unable to distinguish it.

It has always been a matter of surprise to me considering the great thickness of brackish or fresh-water strata connected with our Palæozoic Coal Measures, that examples of a *Spirorbis*, representing the adherent *S. carbonarius*, Murchison, of the European beds of more or less similar age have never been discovered.

Order—Tubicola.

Family—SERPULIDÆ.

Genus—SERPULA, *Linnæus*, 1758.

(Syst. Nat., Ed. X, p. 786.)

SERPULA TESTATRIX, *sp. nov.*

Pl. XVIII, Figs. 4 and 5.

Sp. Char.—Tube minute, coiled, of four or five irregular whorls, the exterior projecting above the inner ones, and all in contact, without a perspective umbilicus.

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[1] Geol. Mag., 1890, VII (3), p. 199.

[2] *See* R. Etheridge, junr., Geol. Mag., 1880, VII (2), p. 258, t. 7, f. 9-11.

Obs.—It is difficult to assign characters to a species whose fellows all resemble one another as closely as do those of *Serpula;* but as this is the first yet noted from the Permo-Carboniferous Series of New South Wales, I venture to assign the above name to it. The manner in which the tube is coiled on itself allies this species closely with *S. torbanensis*, mihi,[1] a worm very characteristic of a black band winstone above and below the celebrated Torbane-hill mineral at Bathgate, Scotland.

Locality and Horizon.—Two miles north-west of Mount Vincent, near East Maitland, Co. Northumberland (*C. Cullen*):—Upper Marine Series.

Section.—*Arthropoda.*

Class.—**CRUSTACEA.**

Sub-Class.—**Entomostraca.**

Order.—**Ostracoda.**

Family.—*LEPERDITIDÆ.*

Genus.—CARBONIA, *Rupert Jones*, 1870.

(Geol. Mag. VII., p. 218.)

CARBONIA AUSTRALIS, *sp. nov.*

Pl. XXI, Figs. 9–12.

Sp. Char.—Carapace oval-oblong; anterior and posterior ends practically equal, although one appears to be very slightly more pointed than the other; muscle spot large, circular, with a contiguous granular wrinkling; surface pitted and wrinkled microscopically.

Obs.—Specimens of this interesting form, collected by Mr. John Waterhouse, M.A., were forwarded to Prof. T. Rupert Jones, F.R.S., who, after a careful examination with Mr. J. W. Kirkby, pronounced them a possible *Carbonia*. The valves are so firmly embedded in the matrix that it was found impossible to obtain an absolutely correct outline, but it is believed

[1] Geol. Mag., 1880, VII (2), p. 364, t. 7, f. 33.

that the present figures, from sketches contributed by Prof. Jones, are accurate. He remarks, in a letter to the Writer, that *Carbonia* "is the only genus to which they are nearly allied."

Locality and Horizon.—Wollombi Road, ten miles south of West Maitland, Co. Northumberland (*J. Waterhouse, M.A.*) :—**Upper Marine Series.**

Family.—CYPRIDINIDÆ.

Obs.—A species of *Entomis* was recorded by the late Prof. de Koninck under the name of *E. Jonesi*, from the Muree Rock, Upper Marine Series. It is allied to *E. nitida*, F. A. Roemer, of the German Devonian Rocks.

Genus.—ENTOMIS, *Rupert Jones*, 1861.

(Mem. Geol. Survey Scotland, No. 32, p. 137.)

Entomis Jonesi, *De Koninck.*

Entomis Jonesi, De Koninck, Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 346, t. 24 f. 6, a and b.

Sp. Char.—Carapace valves oval-oblong, convex, a little attenuated anteriorly in outline; dorsal margin nearly straight; ventral margin curved; anterior and posterior ends nearly equal, but the latter probably somewhat the larger; sulcus frequently indistinct, separating the valves into two unequal portions, the posterior the larger; surface smooth.

Obs.—The sulcus in De Koninck's figures is too long and broad, and should possess less dimensions. I have examined specimens from the typical locality, and feel sure that we have both had before us similar specimens. It occurs on weathered surfaces of the Muree Rock, both as external impressions and internal casts, freely associated with the little bodies called by De Koninck *Polycope simplex*. The present species differs from *Entomis nitida*, according to De Koninck, in the transverse and longitudinal measurements.

Locality and Horizon.—Tokal Quarry, Paterson (*Prof. T. W. E. David, B.A.*) :—**Muree Rock, Upper Marine Series.**

Family.—POLYCOPIDÆ.

Obs.—Weathered surfaces of the Murce Rock are in places covered with more or less depressed pea-like bodies. These were referred[1] by Prof. de Koninck to the British Carboniferous Limestone Ostracod *Polycope simplex*, J. and K. I much regret that I cannot accept these little organisms, of which the collection contains a large number of specimens, as Ostracoda. They appear to me to bear evidence of an undoubted Molluscan affinity, and are probably the fry of Pelecypoda. In this view I am fortified by the opinions of Profs. T. R. Jones, and T. W. Edgeworth David.

In the first place De Koninck's description is not that of the fossils he had before him, but is a free rendering, and in some points word for word, with that of the species given by Messrs. Jones, Kirkby, and Brady, in their "Monograph of the British Fossil Bivalved Entomostraca from the Carboniferous Formations"[2]. The Molluscan affinity is based on the following evidence:—

a. The generally oval form is irregularly so within certain wide limits, *i. e.*, it does not show the defined regularity it should, to bring the organisms within the diagnosis of *Polycope*.

b. A curved striated dorsal area exists in all the specimens, large and small, similar to that of many so called Monomyarian molluscs.

c. The largest examples seen begin to take on the appearance of a Mytiliform or Inoceramiform shell.

d. Incipient umbones can be traced in many specimens.

A close inspection of De Koninck's Fig. 7 will reveal the incipient umbones, and the dark shadow surrounding each, representing the cast of the striated area. It is more than probable that these are the fry of a species of *Aphania*, or even perhaps an *Aviculopecten*.

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[1] Foss. Pal. Nouv.-Galles du Sud. 1877, Pt. 3, p. 346, t, 24, f. 7 and 7a.

[2] Pt. 1, 1874, p. 54, (Pal. Soc).

Family—CYTHERIDÆ.

Obs.—A species of the type genus *Cythere* was many years ago recorded[1] by Sir F. McCoy, from Dunvegan. Comparing it with the British forms of the same species, he says: "The agreement in outline, central hollow, and its little marginal tubercle, &c., being absolutely perfect, and admitting of no doubt," when compared with the former. I have not met with the species, *C. impressa*, McCoy.

Family—CYPRIDÆ.

Obs.—The genus *Bairdia* represents this Family by two species in our Carboniferous, or Permo-Carboniferous beds: *B. affinis*, Morris,[2] and *B. curtus*, McCoy.[3] The first is from Booral, on the Karuah River, collected originally by the late Count Paul de Strzelecki; the second was described by McCoy from Dunvegan.

Order—Trilobita.

Family—PROETIDÆ.

Obs.—Until the appearance of De Koninck's work, the only Trilobite of Carboniferous age described from New South Wales was McCoy's *Brachymetopus Strzelecki*,[4] from Dunvegan. Prof. De Koninck figured two others, referring them to the European *Griffithides seminiferus*, Phill.,[5] and *Phillipsia Eichwaldi*, Fischer.[6] With the second of these I am unacquainted, but the fragment figured under the first name, with the pustulose test, is possibly Phillips' species, although more perfect material must be obtained before a definite opinion can be passed. The fossil described as *P. Eichwaldi* does not, in my opinion, appertain to that species, but is more probably identical with a *Griffithides* I have named *G. Sweeti* from the Permo-Carboniferous rocks of Queensland. Small tubercles or pustules are visible on the glabella in De Koninck's figure cited, similar to those of the Queensland species.

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[1] Ann. Mag. Nat. Hist., 1847, XX, p. 229.
[2] Strzelecki's Phys. Descrip. N. S. Wales, &c., 1845, p. 291, t. 18, f. 10.
[3] Ann. Mag. Nat. Hist., 1847, XX, p. 229.
[4] Ann. Mag. Nat. Hist., 1847, XX, p. 231, t. 12, f. 1.
[5] Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 348, t. 24, f. 9.
[6] *Griffithides, Loc. cit.*, p. 350, t. 24, f. 8.

The five or, perhaps, even six species, known to me personally in Queensland and New South Wales are briefly distinguished as follows[1] :—

Phillipsia dubia, *Etheridge.*[2]—Pl. XXI, Figs. 1–4. Glabella long, more or less pyriform, impinging on the anterior border of the shield. Pygidium generally triangular; thoracic axis narrow and broad, 18–20 segments. *New South Wales and Queensland.*

Phillipsia Woodwardi, *Eth. fil.*—Glabella broad and round, separated from the anterior border by a deep channel, (?) surface pustulose. Pygidium unknown definitely. *Queensland.*

Phillipsia grandis, *Eth. fil.*—Pl. XXI, Fig. 5, and Photo-lith No. 5 p. 5 Glabella unknown. Pygidium very large, semicircular, and generally and gently convex; axis broad, about fourteen segments. *New South Wales and Queensland.*

Phillipsia, *sp. ind.* (*a*).—Pl. XXI, Figs. 6–8. Glabella unknown. Pygidium more or less oval with the general characters of *P. grandis*, but much smaller, and with a larger number of segments in the axis. *New South Wales, and possibly Queensland.*

Phillipsia, *sp. ind.* (*b*).—Pl. XXII, Fig. 14. Glabella unknown. Pygidium with the general characters of the last, and *P. grandis*, but the segments ornamented with rows of very minute pustules. *New South Wales.*

Griffithides Sweeti, *Eth. fil.*—Glabella rounded and pustulose, the basal lobes very prominent, and supplementary ones at the distal ends of the neck segment. Axis of pygidium with from 12–14 segments. *Queensland.*

I am not aware that any Carboniferous Trilobite has been described from West Australia, but our collection has been enriched by the impression of a pygidium, apparently a *Phillipsia*, presented by Mr. Connelly, purporting to come from twenty-five miles west of Coordawandy and the Yaltra Mountains, Gascoigne River, but the matrix does not correspond with that of other fossils from the same locality. On the contrary, it is highly ferruginous and

[1] The Queensland Trilobites will be found described in a work, now passing through the press, by Mr. R. L. Jack and the Writer, "The Geology and Palæontology of Queensland and New Guinea" (Government Printer, Brisbane). See also the additional *Griffithides*, p. 130.

[2] Quart. Journ. Geol. Soc., 1872, XXVIII, p. 338, t. 18, f. 7.

glazed, like those from the Yeeda Station District, Fitzroy River, Kimberley, in the Maelcay Museum, and described by myself.[1] Either, therefore, a mixing of fossils has taken place, or a similar glazed ironstone deposit occurs in the district collected from by Mr. Connelly. The pygidium in question is not distinctly preserved, but appears to possess seven or more axial segments.

The interesting fact now stands revealed that we are unacquainted with the occurrence of Trilobites in New South Wales in any beds that can with certainty be referred to the Permo-Carboniferous. So far they are wholly Carboniferous.

Genus.—PHILLIPSIA, *Portlock*, 1843.[2]

(Geol. Report Londonderry, &c., p. 305.)

PHILLIPSIA DUBIA, *Etheridge.*

Pl. XXI, Figs. 1–4; Pl. XXII, Figs. 12 and 13.

Griffithides dubius, Etheridge, Quart. Journ. Geol. Soc., 1872, XXVIII, p. 338, t. 18, f. 7.

Griffithides dubius, Etheridge, fil., Cat. Australian Foss., 1878, p. 42.

Sp. Char.—Body elongately oval. *Cephalic-shield* more or less semicircular; anterior border flattened, broad, and generally well defined; glabella ob-pyriform, slightly convex, and gently attenuated forwards, extending to, but not overhanging, the anterior border; glabella furrows, all three pairs visible (in casts), the two anterior pairs short and close together, oblique, the anterior pair shortest, and on a level with the anterior termination of the eye, the posterior pair almost circumscribing the basal lobes, which are oblong; palpebral lobes narrow; neck lobe narrow, not greatly differentiated from the glabella, without a tubercle, or supplementary distal lobes. Eye large, markedly semilunar, and highly faceted. Free cheeks small, with wide flat borders. Genal angles obtuse.[3] Thorax.—Axis narrow, very convexly arched; angular in the middle line, distal or outer halves bent downwards. Pygidium large, subtriangular, but varying in degree, axis and pleuræ similar in character to those of the thorax; axis narrow, and rapidly attenuating to

[1] Proc. Linn. Soc. New South Wales, 1889, IV, Pt. 2, p.p. 200 and 202.
[2] Amplified, H. Woodward, Mon. Brit. Carb Trilobites (Pal. Soc.), 1883, Pt. 1, p. 11.
[3] *i.e.* no trace of spines preserved.

an obtuse apex, segments eighteen to twenty, the apical segments slightly emarginate backwards in the middle line; pleuræ fourteen to sixteen, the facets of the anterior segment large, and rather triangular; limb narrow, striate. Test and its sculpture unknown.

Obs.—This species was originally described by Mr. R. Etheridge from a very small and therefore probably young specimen. Such a one I have now before me from the Star Carboniferous Basin, Queensland, collected by Mr. R. L. Jack, corresponding in every particular, but one, with the larger New South Wales examples. The difference lies simply in the number of somites in the pygidium, the Queensland example possessing but eight to ten in the axis, our specimens, on the contrary, being constantly eighteen to twenty. Furthermore, those of the northern form are all emarginate backwards in the middle line, except the two anterior segments. In the southern variety it is the apical six or eight which are so emarginate. The probable explanation of this is that of age. There are also indications of indistinct tubercles along the sides of the axis at the distal or apical end, but so indefinite that too much stress need not be laid on them.

From the British species of *Phillipsia* the present Trilobite is distinguished by the much more oval and longer body, generally larger number of segments, especially in the pygidium, and particularly in the form of the glabella. It approaches nearest to *P. Eichwaldi*, but the glabella of *P. dubia* is again longer and narrower, and our form does not possess genal spines, nor, so far as known, a granular ornament to the test. The resemblance chiefly lies in the somewhat triangular pygidium, although I have never seen a mucronate variety from Australian rocks. In similar terms *P. dubia* differs from the Russian species described by Valerian von Möller,[1] from the Carboniferous Limestone of that country.

The descriptions of the American species I have not full access to, but in its proportions *P. dubia* resembles *P. sangamonensis*, M. and W.,[2] but the glabellas of the two species are wholly unlike. The great increase in the number of coalesced axial segments in the pygidium is similar in *P. major*, Shumard, but the very deep and pointed limb at the axial apex is not present in our species.

[1] Über die Trilobiten der Steinkohlenformation des Ural, &c. *Bull. Soc. Imp. Nat. Moscou*, 1867, No. 1.
[2] Vogdes, The Genera and Species of North American Carboniferous Trilobites. *Ann. N. York Acad. Sci.*, IV, t. 3, f. 8.
[3] Meek in Hayden, Final Report U.S. Geol. Survey Nebraska, 1872, Pt. 2, t. 3, f. 2.

Locality and Horizon.—Binge Berry, Rouchel Brook, Hunter River, Co. Durham (*C. Cullen*); Allyn River, half a mile north-east of Gresford, Co. Durham (*C. Cullen*); Upper Muscle Creek, Musclebrook, Co. Durham (*Prof. T. W. E. David, B.A.*); Torryburn, twelve miles from Paterson (*J. Waterhouse, M.A.*) :—Carboniferous.

Phillipsia grandis, *sp. nov.*

Pl. XXI, Fig. 5; and Photo-litho. No. 5.

Sp. Char.—Cephalic shield and thorax unknown. Pygidium very large, one inch three-eighths broad, and one inch one-eighth long, semi-circular, gently convex; axis broad, tapering rapidly, segments about fourteen; pleurae very gently convex, along the anterior edge as wide as the axis, the ridges of the coalesced segments reaching the margin of a narrow, steep limb. Test apparently unornamented.

Obs.—Judging from the relative proportions of thorax, pygidium, and cephalic shield in *Phillipsia dubia*, the present pygidium must represent a Trilobite nearly three inches in length, an exceedingly large size for a Carboniferous form; unfortunately, the pygidium is the only part known, and in consequence the generic identity must for the present remain in doubt. In all probability the nearest species to this in size is *Phillipsia major*, Shumard, of which Vogdes[1] gives the following measurements :—"Width of pygidium, $1\frac{20}{100}$ inch; length, $1\frac{10}{100}$."

Fig. 5.

The late Mr. C. S. Wilkinson collected a fragmentary pygidium (Pl. XXI, Fig. 5) near Mount Morgan, one inch in length, as preserved, which probably indicates the presence of this species in Queensland.

[1] Vogdes, *loc. cit.*, p. 85.

We are indebted for the loan and knowledge of *P. grandis* as a New South Wales species to Mr. D. A. Porter, of Tamworth, in whose cabinet the specimen given in the Photo-lithograph is preserved.

Locality and Horizon.—Swain's Conditional Purchase, about seven miles south-east of Carroll, Co. Buckland (*D. A. Porter*):—Carboniferous.

Phillipsia, *sp. ind.* (*a*).

Pl. XXI, Figs. 6–8.

Obs.—I have separated from the foregoing species a few pygidia, having a more oval outline, flatter, or less convex surface, and a very much wider axis, with from sixteen to eighteen coalesced segments. The flatter surface and wider axis seem to me to be clearly indicative of a distinct species. In two cases the test is preserved, and is unornamented.

A pygidium very much resembling this has been forwarded to me by Mr. R. L. Jack from the Stanwell beds, near Rockhampton.[1]

Mr. Geological Surveyor G. A. Stonier has also collected a pygidium in Portion 7, Parish of Goonoo Goonoo, Co. Parry, which in outline corresponds to the above figures, but indications of segmentation are very faintly preserved.

Locality and Horizon.—Binge Berry, Rouchel Brook, Hunter River, Co. Durham (*C. Cullen*); Upper Muscle Creek, Musclebrook, Co. Durham (*T. W. E. David, B.A.*):—Carboniferous.

Phillipsia, *sp. ind.* (*b*).

Pl. XXII, Fig. 14.

Obs.—Cephalic shield and thorax are unknown. Pygidium of medium size, five-eighths of an inch long, fourteen segments on the axis, and twelve on the pleuræ; the general outline is much flattened, and there is a narrow, flat border. Each segment of the axis, and each rib of the pleuræ are ornamented with very minute intermingled pustules.

[1] Geol. and Pal. Queensland and New Guinea, *in lit.*, t. 8, f. 6.

As I have failed to trace sculpture on any other pygidium from New South Wales, strictly referable to *Phillipsia*, this example is placed on one side as possibly distinct from the others. It may be related to the Trilobite I have named from Queensland, *Griffithides Sweeti*. As regards its general characters, it certainly is more nearly allied to the last indicated species (Pl. XXI, Figs. 6 and 7), and *P. grandis* (Pl. XXI, Fig. 5) in the flattened axis and pleuræ, than it is to *P. dubia* with its strongly arched subdivisions.

Locality and Horizon.—Greenhills, Paterson to Dungog Road, Co. Durham (*C. Cullen*):—Mirari Limestone, Carboniferous.

Genus—GRIFFITHIDES, *Portlock*, 1843.

(Geol. Report Londonderry, &c., p. 310.)

Griffithides? *sp. ind.*

Pl. XXII, Figs. 15 and 16.

Sp. Char.—Pygidium semi-circular to ovate-triangular; axis long, arched, of thirteen segments and a terminal appendage, gradually tapering; pleuræ of ten segments, curved downwards laterally; limb nearly vertical, of about equal width throughout, except at the immediate apex; axial groove deep and wide, the pleuræ and limb separated by other very marked lateral grooves. Ornamentation consists of tubercles arranged in a single transverse series on each segment; on the axis and pleuræ four to eight, but commonly six, graduating downwards; on the limb, two opposite each pleura, the inner always much the larger of the two.

Obs.—This pygidium is obviously allied to *Griffithides seminiferus*, Phill. sp.,[1] and possibly to the Australian fossil figured under that name by the late Prof. de Koninck.[2] From the species proper it is at once distinguished by the absence of the tuberculated limb; but as Prof. de Koninck made no mention of a similarly ornamental limb, I am constrained to regard it as distinct from the already known New South Wales fossil also. As I am only acquainted with the pygidium, I refrain from proposing a specific name, although satisfied that the Trilobite is quite different from any of our Australian forms so far correctly determined.

[1] Ill. Geol. Yorkshire, Pt. 2, 1836, t. 22, f. 8–10. Woodward, Mon. Brit. Carb. Trilobites (Pal. Soc., Pt. 1, 1883, t. 5.

[2] Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 348, t. 24, f. 9, 9*a*.

The ornamenting tubercles were, I believe, in the perfect condition prolonged into spines. In Pl. XXII, Fig. 16, is figured the right pleura of a tail in which the tubercles are so extended.

Now a word as to Prof. de Koninck's *Phillipsia seminifera*, Phill. That it is not *Griffithides seminiferus*, Phill, sp., as this Trilobite is now called, is more than probable; indeed, the description of the glabella given by De Koninck, wherein he refers to the middle and anterior glabella grooves ("les sillons moyens et antérieur"), sets at rest in the negative the question of this being a *Griffithides* even. In all probability De Koninck's Trilobite and the present pygidium are identical, and for this reason I have placed after the generic name at the head of these paragraphs a note of interrogation.

Locality and Horizon.—Gardner and Cameron's Conditional Purchase, Back Creek, Parish of Doon, Co. Durham (*Pres. E. Twynam, Chief Surveyor*); Kean's Gully, Parish of Tudor, Co. Durham (*Ibid*); Rouchel Brook, Hunter River, Co. Durham (*Ibid*) :—Carboniferous.

ADDENDUM.

Family—PLATYCRINIDÆ.

Obs.—Pl. XX, Fig. 8 represents a portion of a calyx, referable, I believe, to *Platycrinus*. The figure is defective in so far that the downward curvature of the exposed basals is not shown, nor are the excavated margins for the arms in the two radial plates facing the observer, but between these, and partly resting on both is an interadial. The plates are ornamented with radiating lines of very peculiar wart-like tubercles, concave at their apices.

The specimen will be refigured and described more in detail.

Locality and Horizon.—Greenhills, Paterson to Dungog Road, Co. Durham (*C. Cullen*) :—Mirari Limestone, Carboniferous.

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EXPLANATION OF THE PLATES.

NOTE.—Unless otherwise stated, the figures are of the natural size; they have been reversed in the process of reproduction.

PLATE XII.

Page.

Palæaster giganteus, Eth. fil. ... ...

A remarkably fine specimen, with the actinial surface exposed.

Ravensfield Quarry, near Farley.

Reproduced by Heliotype.

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PLATE XIII.

Page.

Palæaster Strutchburii, Eth. fil. 73

Fig. 1. The actinial surface exposed, but at the apices of two of the rays the abactinial plates are visible.

Tribrachiocrinus Clarkei, McCoy 90

Fig. 2. Lateral aspect with the heptagonal basal in view.

Fig. 3. The opposite side of the calyx, with one of the hexagonal basals visible.

Fig. 4. The posterior side exhibiting the two posterior basals, the azygous plate, the anal plate, and the bottom plate of the ventral tube.

Portion of a Column 115

Fig. 5. Large stem joints illustrative of one form commonly met with in the Permo-Carboniferous of the Shoalhaven District.

Fig. 6. Transverse view of the same.

Fig. 1, from Ravensfield Quarry, near Farley.
Figs. 2–4, „ Waterworks, West Maitland.
„ 5–6, „ Shoalhaven District.

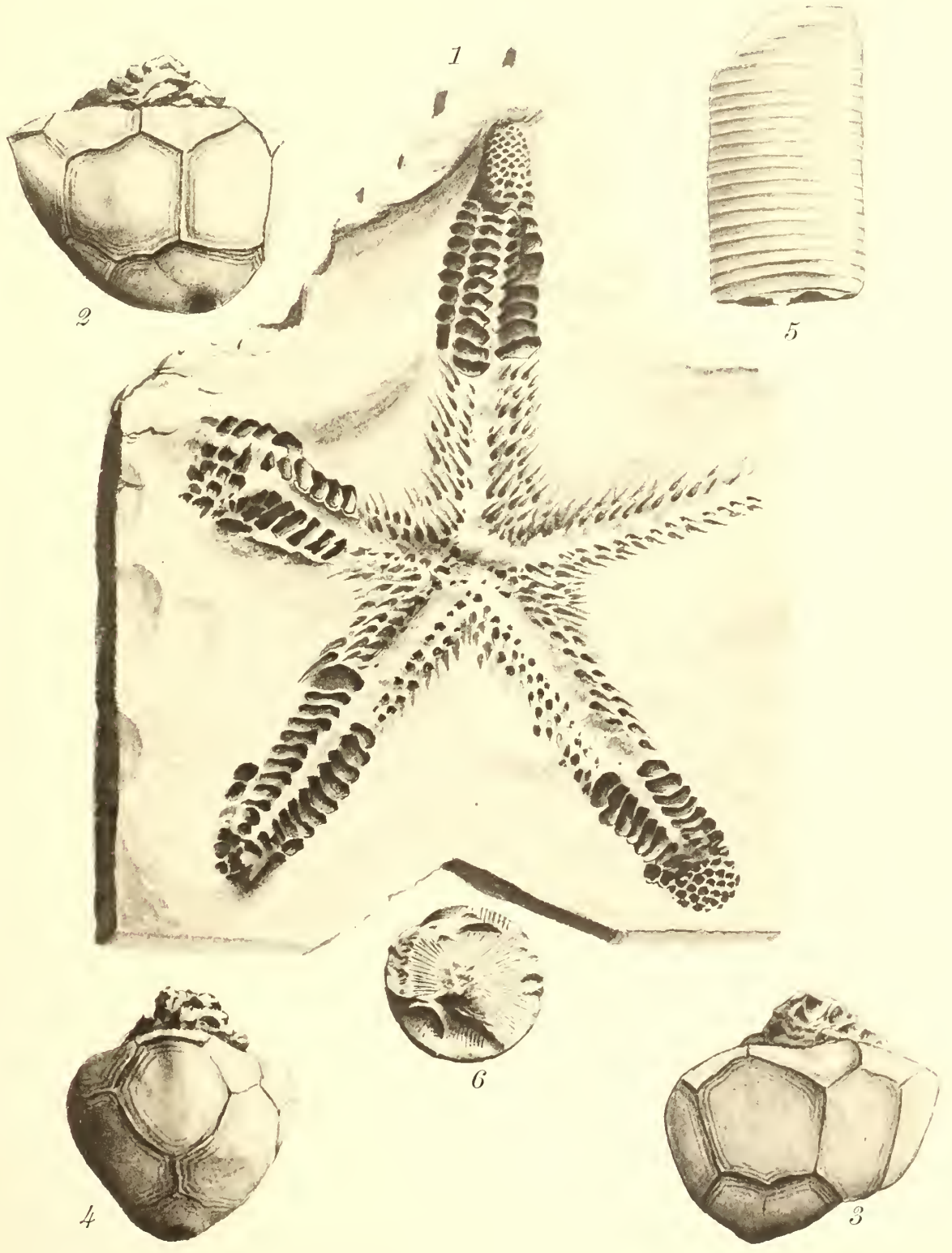
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PLATE XIV.

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Palæaster Clarkei, De Koninck 71

Fig. 1. Impression of the abactinial surface, with the madreporiform plate *in situ*.

Fig. 2. A similar impression, with some of the imprints of the marginal plates preserved.

Tribrachiocrinus Clarkei, McCoy 90

Fig. 3. An internal cast of the calyx, showing the infra-basal plates, the heptagonal basal plate, and the anal plate.

Phialocrinus ? nodosus, Eth. fil. 112

Fig. 4. An internal cast, seen from below, with the five infra-basal and five basal plates in position.

Fig. 5. The same, side view, reversed upwards, to bring prominently forward the large nodes of the basal plates.

Radial Plate ? 116

Fig. 6. Impression of an undetermined radial plate (*? Actinocrinus*), with radiating sculpture.

Basal Plate 116

Fig. 7. Impression of a basal plate (*? Tribrachiocrinus*), the sculpture consisting of tubercles and radiating ridges.

Figs. 1 and 2, from Ravensfield Quarry, near Farley.
3 and 6 „ Nowra.
„ 4 and 5, „ Copper Point, Shoalhaven.
Fig. 7, „ Jamberoo.

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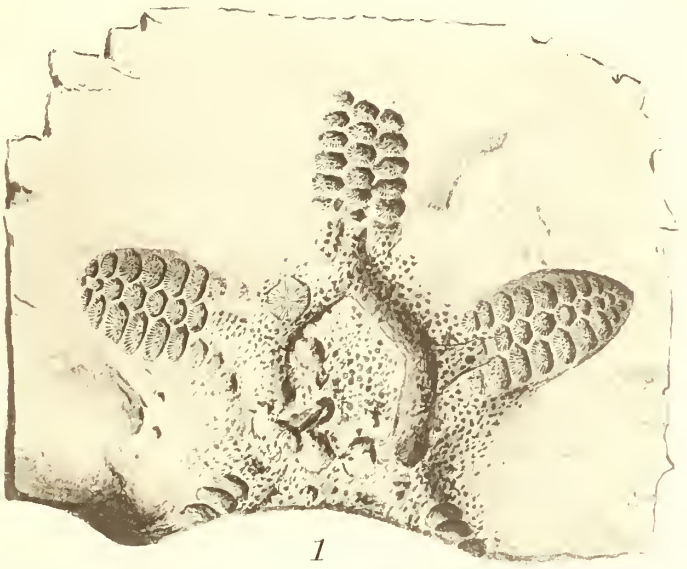

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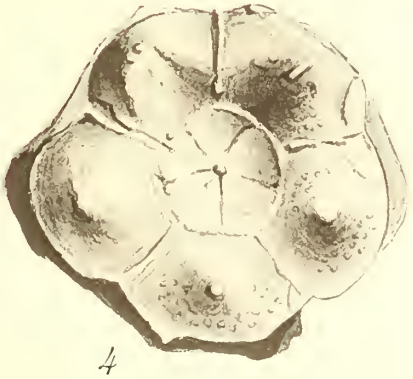

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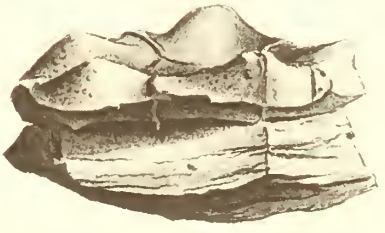

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PLATE XV.

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Archæocidaris Selwyni, Eth. fil. 67

Fig. 1. Ventral surface of the test, as a cast in coarse sandstone, showing the remains of large interambulacral plates, and the peristome occupied by the remains of the masticatory apparatus.

Fig. 2. Portion of the same specimen, in side view.

Fig. 3. A cast, in relief, of some of the interambulacral plates, showing the perforated primary tubercle.

Palæaster Clarkei, De Koninek 71

Fig. 4. Impression of the actinial surface of a large specimen, with well marked petaloid rays, and large adambulacral plates.

Tribrachiocrinus Clarkei, M'Coy 90

or,

Phialocrinus Koninckı, Clarke, sp. 107

Fig. 5. Either the left anterior basal of *T. Clarkei*, or the hexagonal anal-supporting basal of *Phialocrinus Koninckı*, probably the latter.

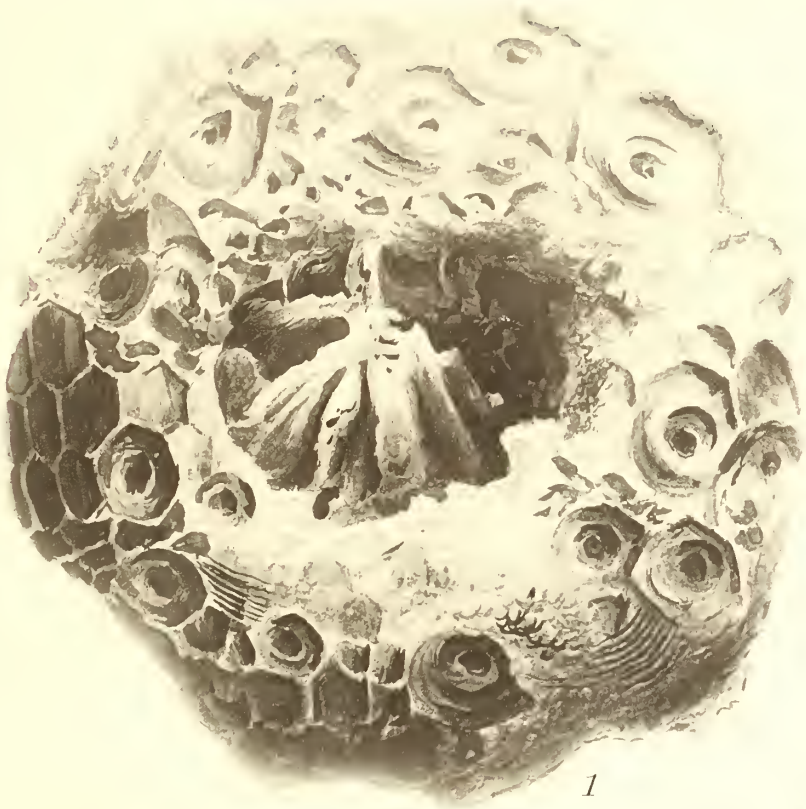
Tribrachiocrinus Clarkei, M'Coy 90

Fig. 6. Heptagonal basal in a decorticated condition, with some of the angles hidden by overhanging matrix.

Fig. 7. One of the hexagonal basals—similarly preserved.

Fig. 8. Left non-arm bearing anterior radial in a similar condition.

Figs. 1–3, from Nowra.
Fig. 4, „ Farley.
Figs. 5–8, „ Wollongong.



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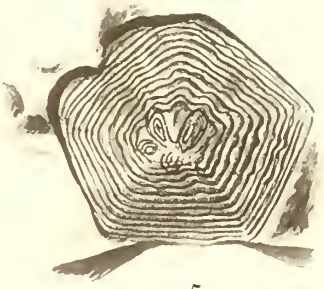

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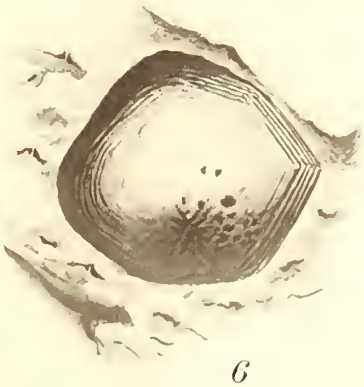

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PLATE XVI.

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Phialocrinus Koninckí, Clarke, sp.... 107

Fig. 1. Internal cast of the calyx, and external impression of the arms in sandstone, anterior side.

Fig. 2. A similar specimen of the calyx only, but the basal plates showing the characteristic bosses, radii, and concentric lines, whilst the radials are radiately sculptured only. The sutures exhibit the line of small nodes along the inter-basal and basi-radial sutures.

Fig. 3. Another like and rather crushed calyx, viewed from the posterior side, with the anal plates in position, truncating the hexagonal basal.

Fig. 4. The base of the same specimen, showing the inverted base for the reception of the infra-basal plates.

Tribrachiocrinus corrugatus, Ratte 95

Fig. 5. View of the base or dorsal surface, a reproduction from an external inpression.

Fig. 6. The upper or ventral surface, showing the three articular surfaces for the arms, and the impressions of disk plates.

Fig. 7. Left half-side, posterior view, exposing the heptagonal basal surmounted by the anal plate.

Fig. 8. Left side view, with basals and radials visible.

Fig. 9. Right side view.

Fig. 10. An internal cast of the calyx, seen from above, with further traces of disk plates.

Basal plate 116

Fig. 11. Impression of a small basal plate similar to Pl. XIV, Fig. 7.

Figs. 1–4, from Nowra.
„ 5–11, „ Jamberoo.

[The originals of Figs. 5–10 are in the Australian Museum.]

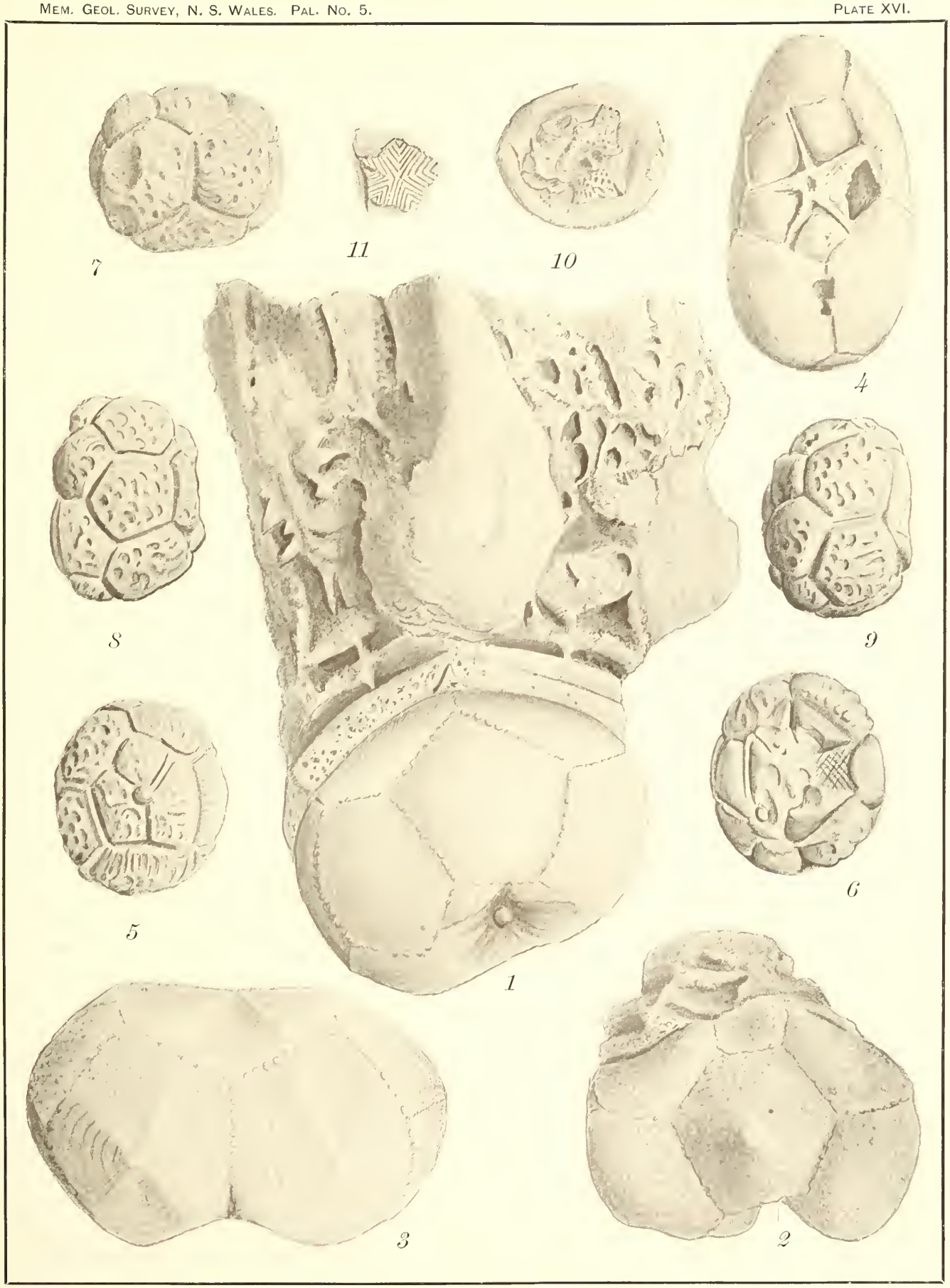
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PLATE XVII.

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Phialocrinus princeps, Eth. fil. 110

Fig. 1. Portion of the calyx, including the infra-basals, four of the basal plates, and one of the radials in relief.

Tribrachiocrinus Clarkei, M'Coy 90

Fig. 2. Right lateral view, showing two large basals in the centre, and the azygous plate to the right.

Fig. 3. The same internal cast taken more from the posterior, in a rather oblique direction, with the azygous plate protruding on the right hand.

Fig. 4. Dorsal view of the same specimen, with the azygous plate shown at the upper end.

Stem. 116

Fig. 5. Portion of a stem with verticillate cirri.

Fig. 1, from Singleton.
Figs. 2–4, ,, Nowra.
Fig. 5, ,, Gerringong.

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PLATE XVIII.

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Phialocrinus princeps, Eth. fil. 110

Fig. 1. Calyx, top stem joint, and portion of the arms in relief.

Stem 116

Fig. 2. Portion of a stem with verticillate cirri articulations.

Perforated stem 117

Fig. 3. Portion of an enlarged or distorted stem with perforation.

Serpula testatrix, Eth. fil. 120

Fig. 4. The test attached to a Crinoid stem.

Fig. 5. The same, x 4

Figs. 1, 3–5, from Mount Vincent.

Fig. 2, „ Shoalhaven District.

[The original of Fig. 1 is in the Branch Technological Museum (Maitland Scientific Society) at West Maitland.]

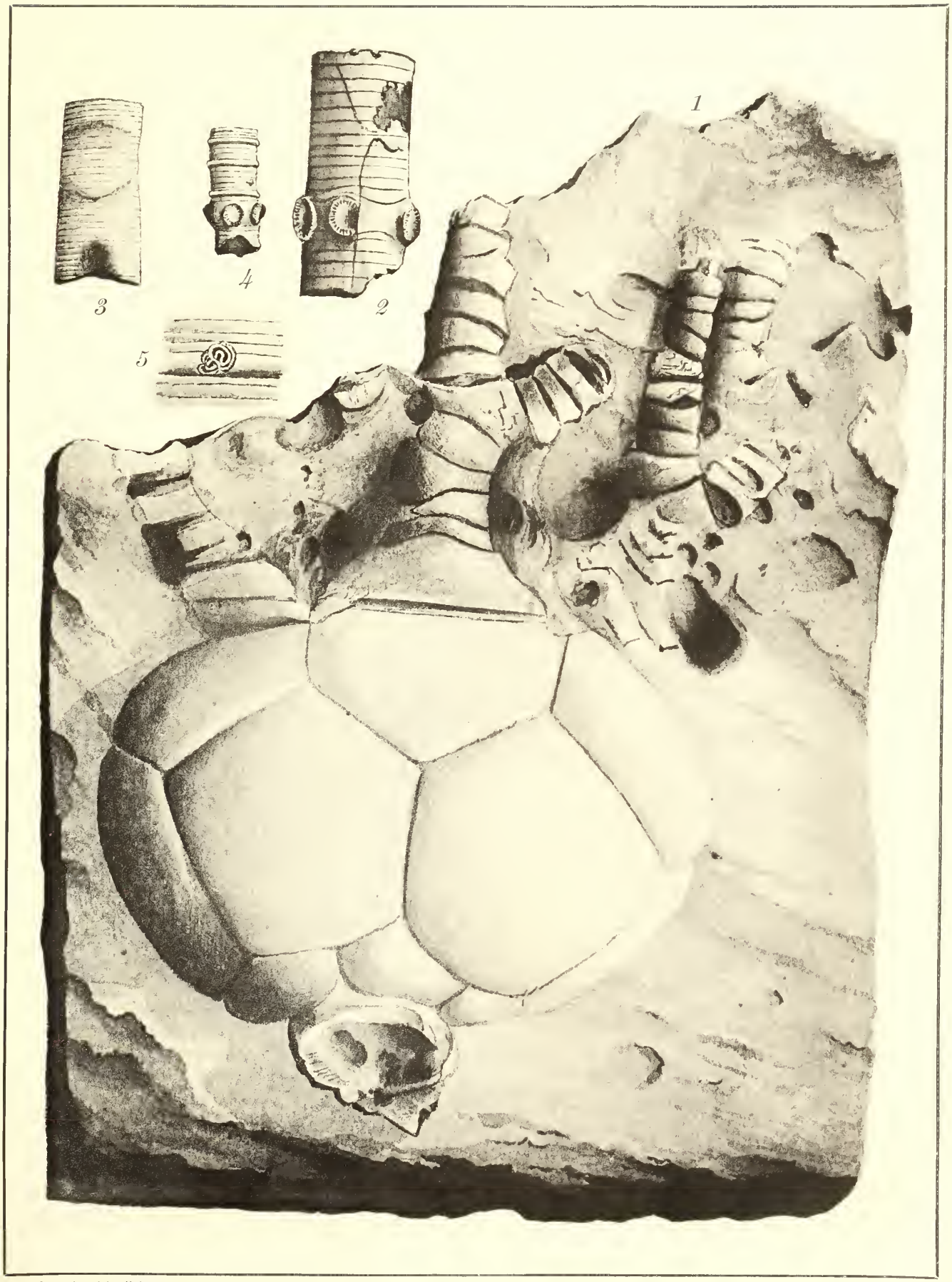
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PLATE XIX.

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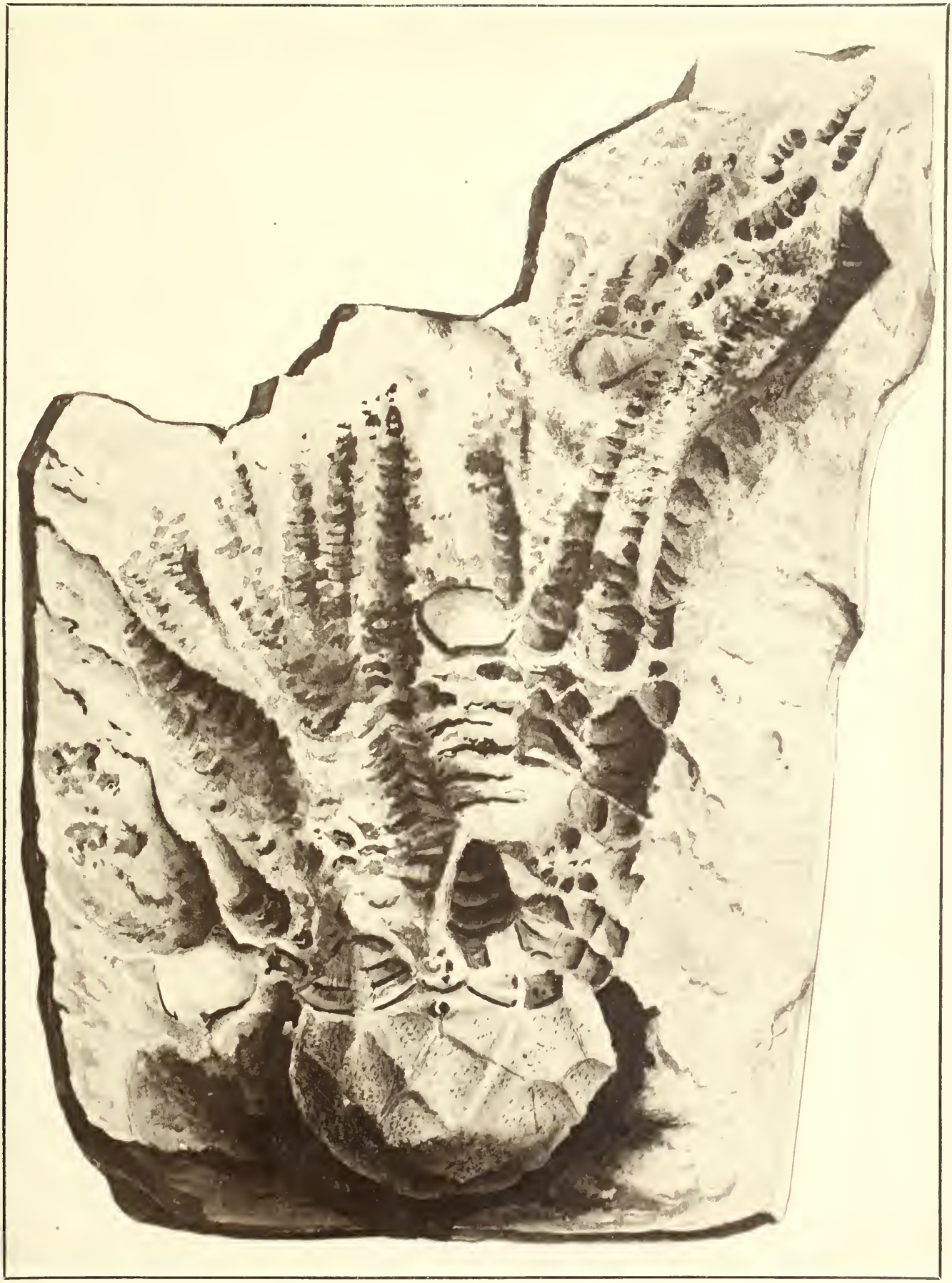
Tribrachiocrinus ornatus, Eth. fil. 94

An internal cast of the calyx, and an impression of the arms in coarse grit from Nowra.



Reproduced by Heliotype. *IIa 64—92*

PLATE XX.

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Phialocrinus? Stephensi, Eth. fil. 113

Fig. 1. Cast of the calyx, seen from the right side, showing portions of the basals, radials, and costals.

Fig. 2. The same specimen, seen from the left side.

Fig. 3. The same specimen, seen from the posterior or anal side.

Fig. 4. The same specimen, seen from "above," or the ventral end.

Fig. 5. The same specimen, seen from "below," or the dorsal end, exposing the infrabasals and basals.

Actinocrinus, sp. ind. 77

Fig. 6. Portion of an internal cast, probably identical with *Actinocrinus polydactylus*, De Kon. (non Miller), from Glen William, N. S. Wales.

Fig. 7. A crushed example of the same species as Fig. 6, in all probability.

Basal cup 131

Fig. 8. Three plates, forming an apparently shallow basal cup, ornamented with radially arranged granules.

Radial Plate 117

Fig. 9. A large radial plate, probably of *Tribrachiocrinus*, allied to *T. corrugatus*, Ratte.

Figs. 1–5, Nowra.
„ 6–8, Greenhills, near Paterson.
Fig. 9, Jamberoo.

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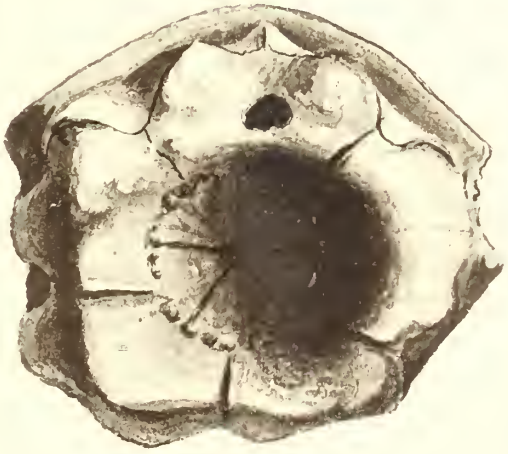

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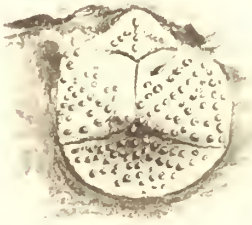

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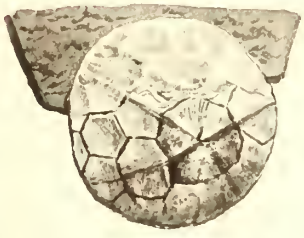

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PLATE XXI.

Page.

Phillipsia dubia, Etheridge... ... ... 125, 126

Fig. 1. A decorticated individual, with half the cephalic shield preserved, of which the glabella is rather pinched up along the middle line, x 2.

Fig. 2. A decorticated pygidium and impression of the glabella of another specimen, showing the true outline of the latter, x 2.

Fig. 3. Glabella and portion of the thorax of a third individual. The outline of the former is intermediate between that of Figs. 1 and 2, x $\frac{1}{3}$.

Fig. 4. The largest known pygidium of this species—a portion of the left pleura wanting, x 2.

Phillipsia grandis, Eth. fil.... ... ... 125, 128

Fig. 5. Portion of a very imperfect pygidium, but with the proportions correctly shown in outline.

Phillipsia, sp. ind. (*a*) 125, 129

Fig. 6. Pygidium, in outline much more semicircular than that of *P. dubia*, and with the axis and pleuræ much less angled, x 2.

Fig. 7. Another example of the same form.

Fig. 8. A third pygidium, imperfect along the lower margin, but differing in a similar manner from *P. dubia*.

Carbonia australis, Eth. fil.... 121

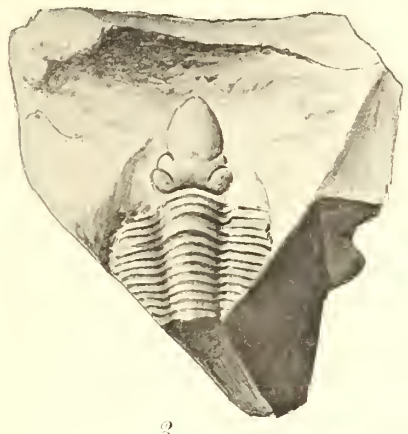
Fig. 9. General side view of valve, x 24.

Fig. 10. Elevation, or edge view, to show the convexity of the valve, x 24.

Fig. 11. End view, x 24.

Fig. 12. Muscle spot, highly magnified.

Figs. 1–4, 6 and 7, from Binge Berry, Rouchel Brook.
Fig. 5, ,, Crow's Nest, Mount Morgan, Queensland.
Fig. 8, ,, Musclebrook.
Figs. 9-12. ,, Wollombi Road, near West Maitland.



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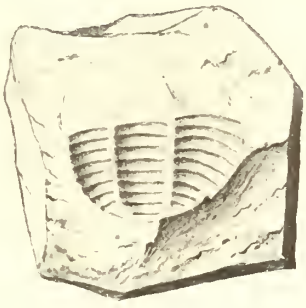

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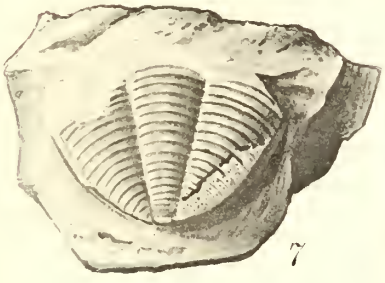

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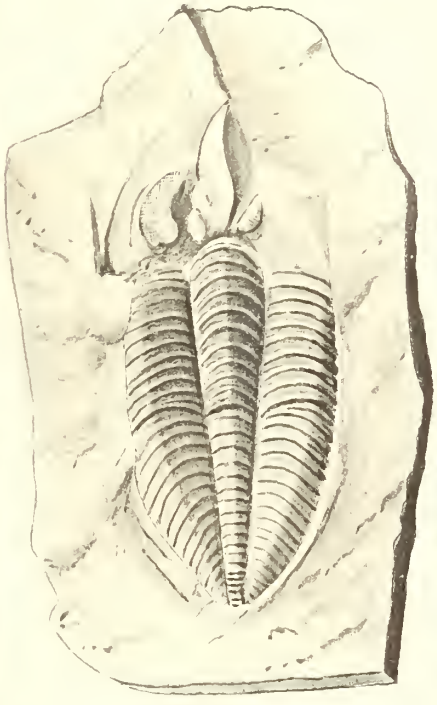

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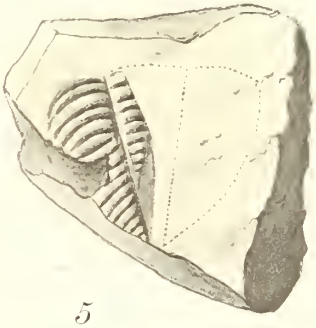

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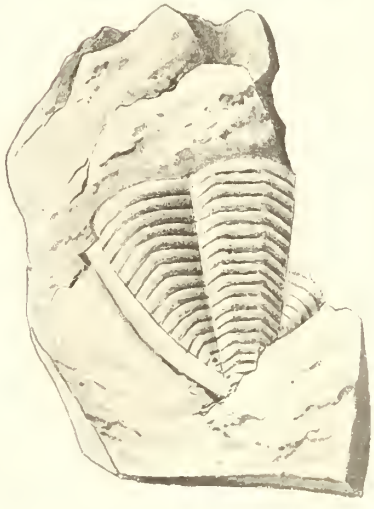

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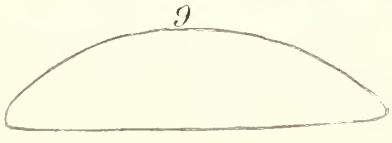

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PLATE XXII.

Page.

Archæocidaris, sp. ind. 69

Fig. 1. An impression of a part of one of the poles of a species allied to, but probably smaller than *A. Selwynii*.

Tribrachiocrinus granulatus, Eth. fil. 97

Fig. 2. Dorsal view of a decorticated specimen resting in its mould and showing the original thickness of the plates.

Fig. 3. The decorticated calyx removed and resting on its ventral surface. The somewhat crushed azygous plate is presented to the observer.

Periechocrinus ? indicator, Eth. fil... 78

Fig. 4. Side view of a decorticated half calyx, showing two basals, and a nearly complete radius within the calyx, of first, second, and third radials.

Phialocrinus princeps, Eth. fil. 110

Fig. 5. A large basal plate, seen from the inside, with the concentric deposition rings visible on the surface and in section, the latter rather oblique. This plate is quite equal in size to either of the basals shown in Pl. XVIII, Fig. 1.

Tribrachiocrinus Clarkei, M'Coy ?... 90

Fig. 6. Basal plate, seen from the exterior, without ornament, but a depression or pit in the centre.

Fig. 7. Interior of the same plate, showing the concentric structure-ornament.

Fig. 8. Exterior of another rather more convex plate, a radial, probably of this species, a like eccentric partial depression is also visible.

Fig. 9. Interior of Fig. 8.

Fig. 10. First, or bottom plate of the ventral tube, which reposes on the truncate upper edge of the azygous plate, seen on edge in Pl. XIII, Fig. 4.

Fig. 11. Another and similar example, x 2.

Phillipsia dubia, Etheridge... ... ... 125, 126

Fig. 12. Eye, partially preserved to show facets, x 3.

Fig. 13. Section of the thorax.

Phillipsia ? sp. ind. (b) 125, 129

Fig. 14. A pygidium similar in form to those depicted in Pl. XXI, Figs. 6–8, but with the segments ornamented with intermingled granules, x $\frac{2}{3}$.

Griffithides ? sp. ind. 130

Fig. 15. Pygidium showing the tuberculated segments and limb.

Fig. 16. Side view of the right pleura of another specimen, with the tubercles produced into spines.

Fig. 1, 3,	from Dagworth.
Fig. 4,	„ Wallumba.
„ 5,	„ Co. Northumberland.
Figs. 6–10,	„ Minumurra River.
Fig. 11,	„ Ulladulla.
Figs. 12–13,	„ Binge Berry, Rouchel Brook.
Fig. 14,	„ Green Hills, Paterson.
„ 15,	„ Back Creek, Co. Durham.
„ 16,	„ Parish of Tudor, Co. Durham.

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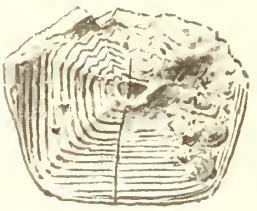

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E. F. PITTMAN, A.R.S.M., UNDER SECRETARY AND GOVERNMENT GEOLOGIST.

PALÆONTOLOGY, No. 5.

A MONOGRAPH

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VOL. II.—PELECYPODA. PART I.—THE PALÆOPECTENS.

BY

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Palæontologist to the Geological Survey of New South Wales, and Lecturer in Palæontology, University of Sydney.

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LETTER OF TRANSMITTAL.

Department of Mines and Agriculture,
Sydney, 2nd January, 1906.

Sir,

I have the honour to submit for publication Part I of Volume II of a Monograph (No. 5 of the Palæontological Series) on the "*Carboniferous and Permo-Carboniferous Invertebrata*," by Mr. Robert Etheridge, J.P., Curator of the Australian Museum, and Mr. W. S. Dun, Palæontologist to the Geological Survey Branch of this Department.

Volume II deals with the Pelecypoda, and this Part describes the Palæopectens occurring in the so-far unproductive Carboniferous rocks and in the Marine beds of our productive Coal Measures.

The description of the fossil forms of these two rock Systems is of very great importance, not only from a general scientific point of view, but also as an aid to the geologists of this Department who are engaged in working out the relations and limits of the respective Formations.

I have the honour to be,
Sir,
Your obedient servant,
EDWARD F. PITTMAN,
Government Geologist and Under Secretary.

The Honourable S. W. Moore, M.P.,
Minister for Mines and Agriculture.

Authors' Preface.

The present Part comprises the first instalment of the Second Volume of the "Monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales."

Parts I and II, which have already been published, deal with the true Corals, Monticuliporoidea, Echinodermata, Annelida, and Crustacea of the Carboniferous and Permo-Carboniferous of the State. These Parts, with two further sections dealing with the Polyzoa and Brachiopoda respectively, will complete Vol. I of the Monograph.

Vol. II will deal with the Pelecypoda as a whole, and will be devoted to those from the Carboniferous and the marine sediments usually known as the Upper and Lower Marine Series of the Permo-Carboniferous System.

It having been found impossible to treat the subject as a whole in a strictly genetic sequence, it is proposed, as in the case of the Monograph of the Silurian and Devonian Corals now in course of publication, to issue small Parts, each of which will comprise all the information available on a certain well-marked generic type and closely allied genera.

With this end in view the first group of fossils to be described is that of the Pectinoid shells, comprising the characteristic Australian genera *Deltopecten*, *Aviculopecten*, and *Entolium*.

The forms dealt with are from the collections of the Geological Survey of New South Wales, the Australian Museum, the University of Sydney, and the Technical College.

The illustrations were prepared in the most part from carefully executed photographs by Mr. A. E. Dyer, in charge of the Photographic Branch, Government Printing Office, and plates XIII–XV were drawn by Mr. F. R. Leggatt, and the whole reproduced under the direction of Mr. W. A. Gullick, Government Printer.

Sydney,
June, 1906.

R. ETHERIDGE, Junr.
W. S. DUN.

INTRODUCTION.

The Aviculopectinidæ of the Carboniferous System of New South Wales are rare, having been found in only a few localities. They are all small, and are closely allied to European and American forms. On the other hand, one of the most striking features of the fauna of the Permo-Carboniferous Marine beds of New South Wales, and in fact of Eastern Australia, is the variety and large size of the Pectinoid shells, one very noticeable fact being the apparent isolation of types displayed by these genera. The Australian members seem to show little or no affinity to those recorded from other parts of the world. There are no species common to the Carboniferous and Permo-Carboniferous in this State; and as regards affinities with extra Australian species, in the case of the Carboniferous forms only two identical with foreign species have passed through our hands, and no instances of close specific resemblance in the case of Permo-Carboniferous forms have been noticed.

These striking fossils soon attracted the attention of the earlier workers on Australian Palæontology.

Professor John Morris in 1845 described[1]:—

Pecten limæformis,
,, Fittoni, } from Tasmania.
,, squamuliferus, }
,, illawarrensis, from New South Wales.

Professor J. D. Dana, in the "American Journal of Science," and in Vol. X of the Report on the "Wilkes Exploring Expedition" in 1849, described from New South Wales[2]:—

Pecten comptus, *Dana*.
,, leniusculus, ,,
,, tenuicollis, ,,
,, mitis, ,,
,, illawarrensis, *Morris*.
,, squamuliferus, ,,

[1] Strzelecki's Phys. Descr. N. S. Wales and V. D. Land (8vo. London, 1845), pp. 277-278.

[2] Am. Journ. Sci., 1847, IV (2), p. 160; Wilkes U. S. Explor. Exped., 1838-42 [1849], X, Geol., pp. 704-705, t. 9, f. 5-9.

At an early date the larger collections made by the Rev. W. B. Clarke, M.A., F.R.S., commenced to be drawn upon, and in 1847 we find McCoy[1] describing from the Permo-Carboniferous of Harper's Hill—*Pecten subquinquelineatus*, and two Carboniferous forms *Pecten ptychotis*, McCoy, and *Avicula tesselatus*, Phill.

In 1872, the late Mr. Robert Etheridge described[2] the large series of fossils from Queensland brought together by Mr. Richard Daintree, and recorded the following Pectinidæ :—

Aviculopecten (?) limæformis, *Morris*.
,, imbricatus, *Etheridge*.
,, multiradiatus, ,,

In 1877, Prof. L. G. de Koninck published the second part of his classical work "Recherches sur les Fossils paléozoiques de la Nouvelle Galles du Sud"[3] dealing with the large collections of Carboniferous and Permo-Carboniferous Invertebrata collected by the Rev. W. B. Clarke. The following forms from the Permo-Carboniferous are dealt with :—

Aviculopecten leniusculus, *Dana*.
,, subquinquelineata, *McCoy*.
,, limæformis, *Morris*.
,, elongatus, *McCoy*.
,, profundus, *De Koninck*.
,, Fittoni, *Morris*.
,, illawarensis, *Morris*.

In the same work he referred a number of Carboniferous forms to European species :—

Aviculopecten consimilis, *McCoy*.
,, depilis, *McCoy*.
,, ptychotis, *McCoy*.
,, Knockonniensis, *McCoy*.
,, cingendus, *McCoy*.
,, granosus, *Sowerby*.
,, Forbesi, *McCoy*.
,, tesselatus, *Phillips*.

As will be seen later on, we have been able to recognise only two of these forms.

[1] Ann. Mag. Nat. Hist., 1847, XX, pp. 298-299, t. 14, f. 2, t. 17, f. 1.
[2] Quart. Journ. Geol. Soc., 1872, XXVIII, pp. 326-327, t. 13, 14.
[3] Mem. Soc. R. Sciences Liege, II (2), pp. 289-302; Engl. trans., Mem. Geol. Surv. N. S. Wales, Pal., No. 6, pp. 228-238.

In 1892 "The Geology and Palæontology of Queensland"[1] was published, and in it are recorded :—

Aviculopecten subquinquelineatus, *McCoy*.
,, limæformis, *Morris*.
Deltopecten illawarrensis, *Morris*.

From the Gympie and Star beds the following forms were recorded and described :—

Entolium, sp. ind.
Euchondria, sp. ind.
Aviculopecten, sp. ind.
,, multiradiatus, *Eth.*
,, Laurienti, *Eth. fil.*
,, Devisii, *Eth. fil.*

A few additional references to the subject, by Mr. R. Etheridge, Junr., Mr. R. M. Johnston, and others, will be found in the systematic portion of this work.

Students of Australian Palæontology—more particularly that of the Palæozoic formations—labour under considerable difficulties, owing to the fact that the types described by Morris, McCoy, Dana, De Koninck and Etheridge (Daintree Collection) are not available for local study and comparison.

The Strzelecki Collection, described by John Morris, is in the British Museum (Natural History); the first Clarke Collection, described by McCoy, is deposited in the Sedgwick Memorial Museum, Cambridge; the Dana collection is in the United States National Museum, Washington; and the even more important collections brought together by W. B. Clarke, and described by De Koninck, was totally destroyed by fire; while the Daintree Collection of Queensland fossils is believed to be also lost. Owing to this series of calamities some points can never be definitely settled, and uncertainty of identity is augmented by the fact that many species were created on single, and others on imperfect, specimens—either fragmentary or in the form of casts.

These disabilities are perhaps most marked in the case of the Permo-Carboniferous Pelecypoda, and more especially in the case of the Aviculopectinidæ. On examination of the type figures, it will be readily seen, for

[1] R. L. Jack and R. Etheridge, Junr. (4to., Brisbane, 1892), pp. 264–270.

instance, that some are very imperfect, others are in the condition of more or less distorted casts and impressions, and in the great majority of cases only one valve is figured.

It will be readily admitted that this condition is more than unsatisfactory and not conducive to accurate determination, and as a tentative solution we propose publishing a series of photographic reproductions of specimens illustrating our interpretation of the different species.

These figures are accompanied by a brief synonymy, diagnosis, a few general remarks on the figures published by other authors, and the affinities of the forms in question.

A similar treatment will be from time to time given to the other Pelecypoda occurring in these beds.

Localities of species given refer only to specimens which have passed through our hands.

The following list comprises the whole of the New South Wales Permo-Carboniferous Palæopectens, either named or described; those in *italics* are synonyms :—

Pecten limæformis, *Morris.*
,, illawarrensis, ,,
,, Fittoni, ,,
,, squamuliferus, ,,
,, subquinquelineatus, *McCoy.*
,, *comptus*, Dana.
,, leniuseulus, *Dana.*
,, mitis, ,,
,, tenuicollis, ,,
,, *lineatus*, Plews.
Aviculopecten profundus, *De Koninck.*
,, *elongatus*, De Koninck.

The following name is rejected :—

1. *Pecten mitis*, Dana,[1] a fragment; at present unrecognisable.

[1] Dana—Wilkes U. S. Explor. Exped., 1849, X (Geol.), p. 705, t. 9, f. 8.

The species described from rocks of Carboniferous age in New South Wales are the undermentioned :—

Pecten ptychotis, *McCoy.*
* Aviculopecten consimilis (*McCoy*), *De Koninck.*[1]
* „ *depilis* (McCoy), De Koninck.
* „ Knockonniensis (*McCoy*), *De Koninck.*[2]
* „ Hardyi, *De Koninck.*[3]
* „ cingendus (*McCoy*), *De Koninck.*[4]
„ granosus (*Sowerby*), *De Koninck.*
* „ Forbesi (*McCoy*), *De Koninck.*[5]
„ tessellatus (*Phillips*), *De Koninck.*
Entolium, sp.

The name in *italics* is a synonym ; those marked by an asterisk we have not seen, and do not deal with.

[1] *Pecten*, McCoy—Synop. Carb. Lime. Foss. Ireland, 1844, p. 91, t. 15, f. 6 ; *Aviculopecten*, De Kon.—Rech. Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 154, t. 22, f. 6, 6a.

[2] *Pecten*, McCoy —*Loc. cit.*, p. 95, t. 17, f. 4 ; *Aviculopecten*, De Kon.—*Loc. cit.*, p. 156.

[3] *Aviculopecten*, De Kon.—*Loc. cit.*, p. 157, t. 22, f. 9.

[4] *Pecten*, McCoy—*Loc. cit.*, p. 90, t. 17, f. 1i ; *Aviculopecten*, De Kon.—*Loc. cit.*, p. 158, t. 22, f. 8.

[5] *Pecten*, McCoy—*Loc. cit.*, p. 93, t. 15, f. 20 ; *Aviculopecten*, De Kon.—*Loc. cit.*, p. 160.

II.—DESCRIPTION OF THE GENERA AND SPECIES.

Class—PELECYPODA.

Order—PRIONODESMACEA.

Section—ISODONTA.

Family—AVICULOPECTINIDÆ.

Genus—AVICULOPECTEN, *McCoy*, 1851.

(Ann. Mag. Nat. Hist., 1851, VII (2), p. 171.)

Observations.—McCoy's definition of his genus is a very clear and comprehensive one, the salient points being an inequivalve, inequilateral shell, more or less produced towards the posterior, the hinge-plate consisting of a narrow facet along the dorsal margin supporting the "cartilage" (resilium), and devoid of a "ligamentary" pit (chondrophore); in other words, in the presence of the one feature and absence of the other lies the principal difference between *Pecten* and *Aviculopecten*.

Some Authors have departed widely from this very clear and precise definition—practically ignoring it. Thus the late Professor James Hall emended the genus to "include those forms which have the hinge-line shorter than the transverse diameter, and both ears well defined."[1] He also proposed *Lyriopecten* for those shells with a "short hinge-line and very small anterior ear," and *Pterinopecten* to include those with "ears not well defined, being simple expansions of the upper lateral margins of the hinge-line." As a matter of fact, differences of this nature are purely empirical, and more of a specific than generic nature; we consider both the above as simple synonyms of *Aviculopecten*. Equally unphilosophical is Dr. W. Waagen's definition of *Aviculopecten*. He says: "I have, as a rule, considered as belonging to the genus *Aviculopecten* those species having the anterior wing smaller than the posterior one; whilst on the contrary, the species with a very large anterior and small posterior wing, were considered by me as belonging to the genus *Pecten*."[2]

[1] Hall—Pal. New York, 1884, V, Pt. 1, No. 1, p. xii.

[2] Waagen—Salt Range Foss. (Pal. Ind.), 1881, I, Pt. 3, p. 300.

Dr. Wheelton Hind removes certain British species from *Aviculopecten*, McCoy, placing them in *Pterinopecten*, Hall, "because they have a narrow linear hinge-plate, and the posterior is not marked off from the rest of the valve."[1] Mere width of the hinge-plate is not a generic character, and Hall in his definition of *Pterinopecten* makes no allusion to it.

A controversy has recently arisen between Mr. G. H. Girty and Dr. W. Hind as to the type species of *Aviculopecten*. This discussion appears to be of very secondary importance, but Mr. Girty is simply following the usual procedure adopted by a very large number of Authors in assuming as the type "the one [species] first mentioned, or *A. planoradiatus*,"[2] or whatever its name may be. In this step his opponent appears to agree with him by saying, in "the absence of any definite indication, it is a good and simple rule to regard the first described species as the type of the genus."[3] The crucial point is, as we have already observed, that McCoy gave a very clear and concise definition of his genus, accompanied by a diagrammatic figure, illustrating the structure so clearly that it appears to be of little moment what the type is.

We adopt the family name Aviculopectinidæ formerly used by one of us[4] in place of the sub-family term Aviculopectininæ proposed by Meek and Hayden,[5] as we believe the articular characters of *Aviculopecten*, *Deltopecten*, *&c.*, more worthy to rank as those of a family than a sub-family. Meek and Hayden remark that "the *Aviculopecten* group seem to form a kind of transition from the *Pectinidæ* to the *Pteriidæ*, and may possibly be distinct from them both, though it is evidently more closely allied to the former than the latter."

The more particular characters of the Aviculopectinidæ will be:— Pectinoid shells possessing an articulus, or hinge, with or without a central chondrophore, but always possessing a resilium occupying a series of linear transverse furrows on the articulus.

Mr. E. Philippi[6] also strongly advocates the inclusion of *Pecten* and *Aviculopecten* in separate families.

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[1] Hind—Am. Geol., 1904, XXXIV, No. 3, p. 201.

[2] Girty—Am. Geol., 1904, XXXIII, No. 5, p. 291; XXXV, No. 5, p. 332.

[3] Hind—Am. Geol., 1904, XXXIV, No. 3, p. 200.

[4] Etheridge, Junr.—Geol. Pal. Q'land, &c., 1892, p. 265.

[5] Meek and Hayden—Pal. Up. Missouri, Pt. 1, 1864, p. 49.

[6] Philippi—Zeitsch. Deuts. Geol. Gesell., 1900, LIV, 1 Heft, p. 74.

Aviculopecten squamuliferus, *Morris*, sp.

(Plate I, Fig. 1; Pl. II, Figs. 4 and 5; Pl. VIII, Fig. 4.)

Pecten squamuliferus, Morris, Strzelecki's Phys. Descrip. N. S. Wales, &c., 1845, p. 278, t. 14, f. 1.

Observations.—The original description is quite insufficient for the recognition of this species, and were it not for the figure, it would be necessary to relegate the name to the rejectamenta. Morris' illustration is the only one we know of, unless the following name is identical:—

1. *Aviculopecten multiradiatus*, Etheridge.[1]—From the imperfect condition of the subject of the late Mr. Etheridge's figure, a reference of this nature cannot be looked on as more than a suggestion, but we think it possible that it and Morris' specimen may have been specifically identical; the type is lost.

We are not able to add many details to the original description of *A. squamuliferus* as we have before us only four examples of the convex valve, all impressions of the exterior, and none perfect. The orbicular valve was ornamented with a very large number of rounded costæ, at least forty-six in one and sixty in another example, irregularly spaced, and similarly arranged as to size. There may be a run of consecutive primary costæ, or the latter may be separated by an occasional interpolated secondary costa, or again, these may follow one another in regular succession between the primary radii. The anterior auricle is fairly large and triangular, the outer margin rounded, and with numerous (six to eight) radiating costæ, sometimes bifurcate; a well-marked byssal sinus separates it from the body of the valve. The posterior auricle is to all intents and purposes as large as the anterior, obliquely truncate along the outer margin, and similarly radiate. Morris says the costæ are "imbricated with small scales," but to us this appears to be a very close continuous concentric lamination or frill imbrication across both costæ and intercostal spaces, equally well marked both on the auricles and the valves proper. Nothing is known of the other valve, nor of the hinge-plate.

Localities and Horizon.—Farley (*J. Waterhouse*); Ravensfield (*J. Waterhouse*); Huon Road, Tasmania; Pokolbin (*C. A. Süssmilch*).—**Permo-Carboniferous—Lower Marine Series.**

Collections.—Mining and Geological Museum, Australian and Technical College (Geological Dept.) Museums.

[1] Etheridge—Quart. Journ. Geol. Soc., 1872, XXVIII, p. 327, t. 13, f. 1.

Aviculopecten profundus, *De Koninck.*

(Plate XI, Figs. 4 and 5.)

Aviculopecten profundus, De Koninck, Rech. Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 161, t. 22, f. 3.

Observations.—Under this name De Koninck figured a poor cast from the Lower Marine Series at Harper's Hill—a large, suboval, and fairly convex right valve, with a large wing-like posterior auricle, apparently without radii.

Notwithstanding that large collections have been made from the locality in question, we have never met with this shell in these gatherings. From other localities, on the other hand, both Upper and Lower Marine, we have before us a few specimens that may be this species, but we are convinced, from the imperfect condition of the type, that any determination under this name will always be more or less open to doubt.

The specimens we tentatively refer to *A. profundus*, are large, suboval, convex valves, and when devoid of auricles by no means unlike our *A. Mitchelli*. The valves were equally convex, the posterior auricles in both valves very large, flattened, rounded on the outer margins, and extended as far as, if not further, than the posterior edges of the valves, with wide but not deep emarginations below the posterior slopes; the posterior auricle of the right valve was out of all proportion to that of the anterior. The anterior auricle of the right valve (that of the left is unknown) is small and rectangular, and there is no apparent byssal sinus. The surface of the right valve bears from forty to fifty costæ, which appear to be irregularly developed, in that they are sometimes all primary, at others divisible into primary and secondary. Both auricles in the right valve are numerously radiate. The whole of the costæ and intercostal spaces, inclusive of those of the auricles, are crossed by regular, close, concentric, non-fluctuating, and very numerous lines, producing a cancellated surface.

If our conception of De Koninck's species be the correct one, it certainly differs from all other Australian Palæopectens, not even excepting *A. squamuliferus*, Morris, which it otherwise resemble to some extent in the sculpture.

We have not observed any trace of a chondrophore, and therefore retain this species in *Aviculopecten*.

Localities and Horizon.—Rutherford's Quarry, near Farley; Ravensfield (*J. Waterhouse*).—**Permo-Carboniferous—Lower Marine Series.**

Collections.—Mining and Geological Museum, Australian Museum.

Aviculopecten ponderosus, *sp. nov.*

(Plate V; Pl. XII, Fig. 1.)

Specific Characters.—Shell very large, longitudinally orbicular, heavy, equilateral (when devoid of the auricles); dorsal margin long, nearly equal to the width of the shell. Convex valve (only one known) highly convex; umbo large, prominent; anterior and posterior slopes highly inclined; anterior auricle very large, deeply triangular, with a wide open emargination below; posterior auricle much smaller than the anterior (imperfect in all our specimens). Costæ angular and coarse, with interpolated secondary ribs—two between each pair of primaries. The anterior auricle bears numerous radiating riblets, crossed by equally plentiful transverse, curved lines, which probably extended over the whole valve, producing a sub-decussated pattern. Hinge-plate thick, grooved.

Observations.—This is a large and ponderous shell, but the state of preservation does not permit us to give as extended a description as we could wish. Two examples attain the following dimensions—(*a*) seven and a half inches long by seven inches wide; (*b*) six and three-quarter inches long by six inches wide. On the surface of the valve distinct growth lines are not present, but as these are preserved on the large anterior auricle of at least one specimen, it is presumed they crossed the valve also.

We possess no evidence of the presence of a chondrophore on the hinge-plate, so include the species in the genus *Aviculopecten* provisionally, of which it probably forms one of the largest species known. Putting aside the question of a chondrophore, on comparing *A. ponderosus* with *Deltopecten limæformis*, Morris, we notice the absence of the obliquity of the latter, the heavier and more robust habit, and the total want of any trace of the depression or groove extending obliquely from the umbo. To our minds this form is absolutely distinct from any other Australian Palæopecten.

Localities and Horizon.—Cessnock (*C. Cullen*); Portion 97, Parish Milfield, County Northumberland (*C. Cullen*).—**Permo-Carboniferous—Upper Marine Series.**

Collection.—Mining and Geological Museum.

Aviculopecten Mitchelli, *sp. nov.*

(Plate I, Figs. 1–3; Pl. II, Fig. 1; Pl. X, Fig. 5; Pl. XII, Fig. 5; Pl. XIII, Fig. 3; Pl. XVI, Figs. 2, 3.)

Specific Characters.—Shell longitudinally oval; valves unequally biconvex; auricles very similar in both valves. Left valve the more convex, and tumid; umbo acute, larger than that of the right valve, and raised slightly above the cardinal margin; anterior and posterior slopes very pronounced. Right valve gently convex, becoming flatter towards the ventral margin. Anterior auricles of both valves triangular, moderately large, the outer edges rounded, and a byssal sinus below that of the right valve; posterior auricles small, rectangular, flattened. Costæ comparatively few in number—twenty to twenty-two—of one order and simple, subangular, with broad, rather concave intercostal spaces, or valleys, the whole crossed by strong, close, concentric, wavy frills or laminæ; the posterior and anterior auricles are coarsely costate.

Observations.—We have several specimens of this large and very tumid valve from the West Maitland District, but unfortunately none are perfect. It is, however, so marked a form, and so eminently characteristic of the Lower Marine deposits, that it cannot be passed over in silence. We believe it to be the—

1. *Pecten illawarrensis*, Dana.[1]—The figure represents a large convex valve, but Dana states that both valves are so, and with eighteen to twenty costate; auricles large.

2. *Aviculopecten illawarensis*, De Koninck.[2]—This author figured a shell with the valves in apposition, and refers to the simplicity of the costæ, but in his illustration some of these are unquestionably bifurcate. It was inequivalve, with mutilated auricles, eighteen to twenty costae, and the left

[1] Dana—Wilkes U. S. Explor. Exped., 1849, X (Geol.), p. 705, t. 9, f. 9, 9*a*.

[2] De Koninck—Rech. Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 163, t. 22, f. 1

valve more convex than the right. He further states that for a third of the breadth in the left [right], or less convex valve, towards the ventral margin, the surface is depressed and nearly flat.

In referring the fossils figured by Dana and De Koninck to the present species, rather than to *Pecten illawarrensis*, Morris, we are influenced by the following considerations:—(1) This is the only large Palæopecten we are acquainted with from Harper's Hill; (2) the same locality was given by both the above authors; (3) we have never seen any shell that could satisfactorily be referred to *P. illawarrensis* from the Illawarra; (4) the outline of *A. Mitchelli* is longitudinally-oval, as opposed to the broad transversely-oval outline shown in Morris' figure, notwithstanding that it represents only portion of a valve; (5) both Dana and De Koninck represent such a longitudinally-oval, pauci-costate form.

The conclusion we have arrived at is, therefore, that Dana's identification is incorrect, and De Koninck was misled thereby, for it is certain, as far as it reasonably can be, that both described similar shells. The only point of discrepancy between the valves known to us and De Koninck's figure of the same is that in the latter some of the costæ are bifurcate, whilst in ours they are invariably simple.

We name this *Aviculopecten* in honour of Sir T. L. Mitchell, at one time Surveyor-General of this State, who was the first to collect fossils at the historic locality of Harper's Hill during one of his memorable exploratory expeditions in 1831 in search of the "Kindur" River.[1]

Localities and Horizon.—Portion 217, Parish Pokolbin (*C. Cullen*); Harper's Hill; one mile north of Comerford's Quarry, West Maitland (*T. W. Edgeworth David*); Allandale (*C. Cullen*); Portion 18, Parish Allandale (*C. Cullen*); Portion 33, Parish Pokolbin (*C. Cullen*); Jones' Selection, Cranky Corner, Portion 8, Parish Stanhope, County Durham (*W. S. Dun*); Allandale Road (*C. A. Süssmilch*).—**Permo-Carboniferous—Lower Marine Series.**

Collections.—Mining and Geological Museum, Australian Museum, and Geological Dept., Technical College.

[1] Mitchell—Three Exped. Int. E. Austr., 1838, I, p. 14.

Aviculopecten tenuicollis, *Dana*, sp.

(Plate XIII, Figs. 10-12; Pl. XIV, Fig. 5.)

Pecten tenuicollis, Dana, Am. Journ. Sci., 1847, iv (2), p. 160.

Pecten tenuicollis, Dana, Wilkes U. S. Explor. Exped., 1849, X (Geol.), p. 705, t. 9, f. 7, 7*a*.

Observations.—Dana figured an imperfect left valve, the anterior auricle broken, the posterior wanting. He described it as suborbicular, with twenty-four slender, subacute, smooth costæ, intermediate secondary costæ, and flat intercostal spaces. It is the—

1. *Aviculopecten tenuicollis*, Eth. fil.[1]—Several specimens were described from the Pindan Sands of the neighbourhood of Derby, North-West Australia. They present the general features of the species, supplemented by the presence of latilaminæ.

2. *Aviculopecten tenuicollis*, Eth. fil.[2]—Additional examples from Western Australia indicate that in addition to the latilaminæ the costæ were intersected by fine, close, flat, frill-like laminæ, rendering the costæ slightly spinose.

We find it impossible to confine our determinations strictly within Dana's definition of his species. He speaks of "the specimen"; we have several before us. We find revolving around specimens similar to Dana's figure, a number with the same outline and same form of costæ, but differing amongst themselves in the number of the latter, and to some extent in the length of the posterior aurieles; these we regard simply as varieties.

The suborbicular or scallop-shaped left valve is convex, equilateral (omitting the aurieles), the anterior and posterior slopes converging rapidly to the umbos, the anterior slopes sharp, and clearly defining the aurieles from the bodies of the valves; the umbos acute, and the dorsal margins long, but barely as wide as the valves. The anterior aurieles are large, deeply triangular, flat, and with a rounded outer margin, not separated off by a byssal sinus, but simply by an emargination. The posterior aurieles are elongately triangular, with sigmoidally curved outer margins, but they

[1] Etheridge, Junr.—Proc. Linn. Soc. N. S. Wales, 1889, IV (2), p. 203.

[2] Etheridge, Junr.—Bull. Geol. Survey W. Austr., 1903, No. 10, p. 23, t. 3, f. 3 and 4.

neither extend laterally as far as the posterior lateral margins of the valves nor terminate in an extended point or mucro. The costæ are very numerous but variable in number, and both primary and secondary, the latter interpolated. In all, the costæ vary from thirty-five to fifty; the anterior auricles are radiate, and the posterior apparently plain. The hinge-plate is quite linear, with delicate resilium furrows.

We have not observed frill-like decussations in any of our New South Wales examples, but they were quite apparent in those from Western Australia examined by one of us. We have not seen specimens of the right valve.

Localities and Horizon.—Ravensfield (*J. Waterhouse, T. W. Edgeworth David*); Farley (*J. Waterhouse*).—**Permo-Carboniferous—Lower Marine Series.**

Collection.—Mining and Geological Museum.

Aviculopecten, *sp.*

(Plate XV, Figs. 11 and 12.)

Observations.—Amongst the Carboniferous Palæopectens recorded by De Koninck is one referred to *Pecten knockonniensis*, McCoy,[1] of the Irish Carboniferous Limestone. No satisfactory evidence of the existence of this species in Australian rocks has come under notice, but we possess three specimens which may be that described by De Koninck as *Aviculopecten knockonniensis*,[2] but as the description is unaccompanied by a figure, and appears to be taken from nearly perfect exotic material, rather than specimens in the usual imperfect state of our New South Wales fossils, we are completely left in the dark as to the nature of those recorded in the Clarke Collection under this name.

We believe the best preserved of our three specimens to be a left valve, and if this be so, then they are most assuredly not McCoy's species. The valve in question is elongately orbicular, with a large number of fine, equal costæ similar to those of the left valve of *P. knockonniensis*, McCoy, and in addition even finer concentric lines crossing them. This, however, is

[1] McCoy—Synop. Carb. Lime. Foss. Ireland, 1844, p. 95, t. 17, f. 4.

[2] De Koninck—Rech. Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 156.

a feature of the right valve of the Irish shell, in which, on the other hand, the costæ are primary and secondary. From this it will be seen that the characters of the Irish and Australian forms, providing our reading of the above valve is correct, are exactly reversed. The auricles, although small, are highly radiate. In this unsatisfactory state we must leave the matter for further developments.

Localities and Horizon.—Hills to west of Mount Uriari, Parish Somerton, County Parry (*C. Cullen*); near Greenhills, Paterson (*J. Waterhouse*).—**Carboniferous.**

Collection.—Mining and Geological Museum.

Aviculopecten Sprenti, *Johnston.*

(Plate II, Figs. 6 and 7; Pl. XIII, Figs. 1 and 9; Pl. XVI, Figs. 5, 6.)

Aviculopecten Sprentii, Johnston, Proc. R. Soc. Tas. for 1886 (1887), p. 9.

Aviculopecten Sprentii, Johnston, Syst. Acc. Geol. Tas., 1888, p. 115, t. 14, f. 11.

Specific Characters.—Shell suborbicular to fan- or scallop- shaped; dorsal margin as long as the width of the shell; ventral margin broadly rounded. Left valve gently convex; anterior and posterior slopes rapidly converging to the umbo, which is sharp and pointed; anterior auricle moderately large, triangular, the outer margin obliquely rounded, and emarginate only on uniting with the antero-lateral margin, and no defined byssal sinus; posterior auricle large, flattened, wing-like, very long, produced as far as the posterior extremity of the valve, acutely pointed at its posterior-dorsal angle, and with the outer margin deeply emarginate. Costæ are primary, secondary, and tertiary; the primary from ten to fourteen in number, strong, sharp, and angular; the secondary occupy the centres of each intercostal space, with on each side of them a tertiary rib; the anterior ear is multiradiate, and on the posterior there are at least four principal costæ; the whole valve is traversed concentrically in the first instance by latilaminæ, in the second by close frills, which, on passing over the primary and secondary costæ, and on the auricles, rise into acute echinations (almost spines) at regular intervals; there is also a prominent series of denticles along the dorsal margin. Hinge-plate linear.

Observations.—This very handsome shell is one of our most beautiful Palæopectens, and can in no way be mistaken for any other species. In its outline and convexity it approaches *A. tenuicollis*, but the form of the posterior auricle, its sculpture, and that of the valve generally, distinguishes *A. Sprenti*. Whereas the outer edge of the posterior auricle in *A. tenuicollis* is obtusely rounded, the corresponding portion in *A. Sprenti* terminates along the dorsal margin in an acute prolongation.

Another very noticeable feature in the present species is the wide and nearly semicircular ventral margin, the lateral costæ on both sides curving or sweeping outwards in a very marked manner to accommodate themselves to this expansion. This is visible to some extent in Pl. II, Fig. 7, and Pl. XIII, Fig. 9, but is even more conspicuous in Pl. VIII, Fig. 12; the strong radiating costæ of the auricle are also prominent features. The right valve is unknown.

We base our recognition of this species as a New South Wales form as a result of the loan, from Mr. Alexander Morton, Curator of the Tasmanian Museum, of a collection of Palæopectens from the Permo-Carboniferous rocks of that State, amongst which we recognised the type of Johnston's *A. Sprenti*. The figure given in the "Systematic Account" is very inadequate as to details, but the measurements of the figure agree with those of the specimen. The latter is an impression of a left valve, with the body-sculpture clearly preserved - consisting of from sixteen to eighteen primary costæ, with a secondary and two tertiary costæ between each pair. Fine decussating frills cross all these, the points of intersection with the primary costæ slightly enlarged, or subnode-like, indicating the positions of the spines represented in our Pl. VIII, Fig. 12. The auricle, so far as they are preserved, equally correspond with our local examples.

The valve figured on Pl. XIII, Fig. 9, we regard doubtfully as *A. Sprenti*. It displays a similar proportionate breadth of valve, and outward sweep of the costæ, but there is not a sufficiently clear demarcation between them individually to be in strict accordance with those of *A. Sprenti*.

Localities and Horizons.—Hartley Vale (*H. G. Rienits*).—**Permo-Carboniferous—Upper Marine Series.** Farley (*J. Waterhouse*); Harper's Hill (*T. W. E. David*); Rutherford Railway Cutting, 200 yards from Allandale (*C. Cullen*); half a mile from Lochinvar Station (*C. Cullen*); Ravensfield; Lochinvar; near Pokolbin (*C. Cullen*); One Tree Point, Tasmania (*Tasmanian Museum*).—**Permo-Carboniferous Lower Marine Series.**

Collection.—Mining and Geological Museum.

Aviculopecten, *sp.*

(Plate XII, Fig. 1.)

Observations.—We figure for reference purposes an imperfect cast of a right valve, in outline and form of auricles resembling *A. Sprenti*. The costæ, however, are of one order, simple, or occasionally bifurcate. The surface is depressed convex, the anterior auricle large, triangular, with five very strong radiating costæ, and the posterior small and rectangular. The anterior and posterior slopes are steep, and sharply separate the auricles from the general plane of the valve.

We at first took this to be *A. Sprenti*, but the nature of the costæ quite forbids such a union, and we can only conclude that the two shells are distinct, but the material in our hands is not sufficient to enable us to give a complete and satisfactory description.

We have two examples of this form, both internal casts, but neither show the slightest indication of costal spines when in the testiferous condition.

Locality and Horizon.—Half mile from Lochinvar Station (*C. Cullen*).—**Permo-Carboniferous—Lower Marine Series.**

Collection.—Mining and Geological Museum.

Aviculopecten Englehardti, *sp. nov.*

(Plate IX, Figs. 6–11; Pl. XIV, Figs. 6–8.)

Aviculopecten elongatus, De Koninck (non McCoy), Rech. Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 155, t. 22, f. 5.

Specific Characters.—Shell orbicular, but inequilateral, produced anteriorly, sometimes somewhat obliquely so; slightly inequivalve; valves equally convex; cardinal margins shorter than the width of the valves; umbo of the left valve higher and more prominent than that of the right; anterior dorso-lateral margins long, oblique, straight, suddenly rounding-off into the combined semicircular anterior ventral and ventral margins; posterior margins rounded throughout; anterior auricles small, narrow, and triangular, the outer margins obliquely rounded, divided-off by narrow, well-marked byssal notches, and each bearing one strong diagonal ridge, dividing the

auricle unequally; posterior auricles very small, flat, ill-defined, their outer margins oblique and straight. Sculpture of very fine, close, regular concentric lines, crossed by even finer radii, that are only distinguishable by reflected light; latilaminæ wide apart. Hinge-plates linear, and very narrow.

Observations.—As *Aviculopecten elongatus*, De Koninck figured an imperfect right valve believed by him to be referable to *Pecten elongatus*, McCoy,[1] of the Irish Carboniferous Limestone, but he appears to have overlooked the fact that the latter is an equilateral shell, and is not produced anteriorly. De Koninck's specimen lacked the auricles, but the regular convex surface, anterior extension, and wide latilaminæ indicate its identity with our present figures. The latter are obviously allied to *Pecten variabilis*, McCoy,[2] another Irish Carboniferous form, and in a minor degree to our own Carboniferous species, *P. ptychotis*, McCoy.

Dr. C. Diener has figured the left valve of an *Aviculopecten* from the Zewán beds of the Kashmir Valley,[3] which is indistinguishable from *A. Englehardti*.

The outline, and inclination to anterior obliquity, are features of McCoy's genus *Streblopteria*, but in our species there is no trace of the cardinal tooth which distinguishes that genus, and separates it from the other members of the family. Most authors in writing of *Streblopteria* appear to have entirely overlooked the possession of this tooth.

It must be noted that the extension of the anterior ends is much accentuated by pressure, flattened examples displaying a remarkable resemblance to *A. variabilis*, McCoy, but that this extreme degree of obliquity is superinduced is proved by the presence of other uncompressed examples in our collections. Inequality of the valves is markedly exhibited by the projection of the umbo of the left valve above that of the right.

There is a good deal of variability in the relative convexity of the valves of one individual as compared with those of another. This is exemplified in our Pl. IX, Fig. 9, a testiferous right valve, and Pl. XIV, Fig. 6, a similar valve, but an internal cast.

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[1] McCoy—Synop. Carb. Lime. Foss. Ireland, 1844, p. 92, t. 16, f. 9.

[2] McCoy—*Ibid.*, p. 101, t. 16, f. 7.

[3] Diener—Himalayan Foss. (Pal. Ind.), 1899, I, Pt. 2, p. 16, t. 1, f. 3.

Those specimens figured on Pl. IX, Figs. 10, 11, and Pl. XIV, Figs. 6, 7, 8, may be taken to represent an obese form of this species, which appears to be characteristic of the Lower Marine Series.

We name this species in honour of Mr. B. G. Englehardt, of the Department of Public Instruction, a well-known and diligent collector of Permo-Carboniferous fossils in the Illawarra District, to whom we are indebted for many valuable additions to the fauna of that period.

Localities and Horizons.—Cabbage-tree Point, Flat Rock Creek, near Nowra (*C. Cullen*); Railway Cutting, Wollongong (*C. Cullen*); Wollongong (*J. Waterhouse*); near West Maitland (*J. Waterhouse*); Wollombi Road (*J. Waterhouse*); Red Rock, near Drake (*E. C. Andrews*); Branxton.—**Permo-Carboniferous—Upper Marine Series.** M.P. 5, Parish Heddon (*C. Cullen*); ? Farley (*J. Waterhouse*); M.P. 2, Parish Heddon (*C. Cullen*).—**Permo-Carboniferous—Lower Marine Series.**

Collection.—Mining and Geological Museum.

Aviculopecten ptychotis, *McCoy*, sp.

(Plate XV, Figs. 5–7.)

Pecten ptychotis, McCoy, Ann. Mag. Nat. Hist., 1847, XX, p. 298, t. 14, f. 2.

Observations.—A small, orbicular, and subequilateral shell, with gently convex valves, the right exhibiting a narrow, transversely-elongate anterior auricle, rounded on its outer margin, and radiate in the adult, square-ended and plicate in the young, separated from the body of the valve by a deep and narrow byssal sinus; the posterior auricle is rectangular, small, and inconspicuous. Both auricles of the left valve are similar to the posterior of the right. It is—

1. *Aviculopecten depilis*, De Koninck[1] (non McCoy[2]).—This specimen was a right valve, the auricles "striated," the anterior separated off by a straight and well pronounced sinus, the posterior smaller and rectangular.

2. *Aviculopecten Laurienti*, Eth. fil.[3]—It was formerly pointed out by one of us that the shell figured by De Koninck as *A. depilis* could hardly be that of the same name by McCoy, and the name *A. Laurienti* proposed for it. At the same time an error was committed by uniting with the valve resembling De Koninck's figure, a costate specimen as the opposite valve.

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[1] De Koninck—Rech. Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 154, t. 22, f. 7.

[2] McCoy—Synop. Carb. Lime. Foss. Ireland, 1844, p. 91, t. 16, f. 11.

[3] Etheridge, Junr.—Geol. Pal. Q'land, &c., 1892, p. 268, t. 43, f. 3 (non 4.)

The shells now before us are casts of small right and left orbicular valves, both moderately convex. The anterior auricle of the right valve is elongately triangular, its outer margin rounded, longitudinally delicately costate, and cut off by a long, linear, oblique byssal sinus; the posterior auricle is small, rectangular, and ill-defined. The left valve is similar to the right, both auricles are rectangular, and apparently equal in size. There is no sculpture preserved except a few oblique striæ along the anterior margin of one specimen. On the anterior auricle of another there are traces of transverse growth ridges, giving rise to a reticulate sculpture.

In De Koninck's illustration the anterior auricle is narrower than in the corresponding part of any of ours, with a straight lower edge, more nearly resembling that shown in the figure of *A. Laurienti*.

McCoy says that in his *Pecten ptychotis* the left anterior auricle is "square at its extremity," and the latter longitudinally plicate. We regard his figure as representing the young condition and a right valve, and those now under description as the adult state. Although not from the same locality as the latter, *P. ptychotis* was obtained from about the same horizon in the Carboniferous.

Localities and Horizon.—Near Crow's Nest, Mt. Victoria, Mount Morgan, Queensland (*J. Smith*); near Gresford, N. S. Wales (*C. Cullen*).—**Carboniferous.**

Collection.—Mining and Geological Museum.

Aviculopecten, *sp.*

(Plate XV, Fig. 10.)

Aviculopecten granosus, De Koninck (non Sby.), Rech. Pal. Foss. Nouv.-Galles du Sud., Pt. 3, 1877, p. 158, t. 22, f. 10.

Observations.—An imperfect valve was figured by De Koninck, believed by him to be referable to *Pecten granosus*, J. de C. Sby.,[1] without either auricles and with imperfect margins. We have an equally imperfect specimen before us, but similar to De Koninck's figure. In this instance there is no doubt that his description is not that of the fossil figured, but of the more perfect European shell, and it is extremely difficult to decide whether or no the former is the

[1] J. de C. Sowerby—Min. Con., 1827, VI, p. 144, t. 574, f. 2.

latter; we doubt it. At any rate, De Koninck's illustration represents a very inequilateral valve, devoid of auricles, inflated in the umbonal region, and extended backwards into a somewhat flattened posterior end. The costæ are alternately larger and smaller, the former granular, the latter interpolated between the larger, and, apparently, undecorated. The characters displayed by our specimen are precisely similar. To ascribe a name to this shell, with our limited knowledge of it, is quite out of the question.

Locality and Horizon.—Hills to the west of Mount Uriari, Parish Somerton, County Parry (*C. Cullen*).—Carboniferous.

Collection.—Mining and Geological Museum.

Aviculopecten tessellatus, *Phillips*, sp.

(Plate XV, Figs. 8 and 9.)

Avicula tessellata, Phillips, Ill. Geol. York., 1836, p. 211, t. 6, f. 6.

Aviculopecten tessellatus, Morris, Cat. Brit. Foss., 2nd ed., 1854, p. 166.

Avicula tessellata, Eth. fil., Geol. Mag., 1879, VI (2), p. 161 (*Gilbertson type*).

Observations.—In the identity of this shell we are in accord with Professor De Koninck, for, with the material at our disposal, we are quite unable to distinguish our specimens from Phillips' *Avicula tessellata*. It is—

Aviculopecten tessellatus, De Kon.[1]—The latter described both valves, the right being somewhat more convex than the left, twelve to fifteen equidistant costæ, with concentric latilaminæ, producing between them a tessellation of the surface. The anterior auricles are nearly rectangular, and only separated from the bodies of the valves by shallow grooves, that on the right valve divided off by a feeble emargination. The posterior auricles are much larger than the anterior, flattened, and terminating at the posterior lateral angles in acute points; the edges thence emarginate to the swell of the posterior ventral margins.

Our specimens, both left valves, accord in every particular with De Koninck's description. We may add that the costæ on the posterior margins (the ventral and anterior are not fully preserved) terminate outwardly

[1] De Koninck—Rech. Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 160, t. 22, f. 11.

in fine acute free spines. The costæ on our best preserved specimen number eighteen, and are all primary; the latilaminæ are well developed and overlapping. The impression of the hinge-plate is linear and long.

Locality and Horizon.—Torryburn Station, twelve miles from Paterson (*W. H. H. Yarrington and J. Waterhouse*).—**Carboniferous.**

Collection.—Mining and Geological Museum.

Genus—DELTOPECTEN, *Eth. fil.*, 1892.

(Geol. Pal. Q'land, &c., 1892, p. 269.)

Observations.—The hinge mechanism of this genus is well displayed in one of our specimens of *D. leniusculus*, Dana, sp. (Pl. VII, Fig. 2). This is a testiferous example exhibiting a wide gape between the hinge-plates of the two valves left by the absent resilium, and bearing its furrows of attachment, with the central subumbonal chondrophore. It is in the possession of the latter that *Deltopecten* differs from *Aviculopecten*, and thus occupies an intermediate position between the latter and *Pecten* proper; in other words, it possesses the hinge structure of both genera. *Pernopecten*, Winchell, according to Hall,[1] has a "central cartilage pit," but the resilium furrows replaced by "crenulations" on each side of the former below the hinge margin. Again, *Crenipecten*, Hall, possesses the "same cartilage pits throughout its [the hinge-plate] entire length."

Deltopecten limæformis, *Morris*, sp.[2]

(Plate X, Figs. 3 and 4; Pl. XI, Figs. 1 and 2.)

Pecten limæformis, Morris, Strzelecki's Phys. Descrip. N.S. Wales, &c., 1845, p. 277, t. 13, f. 1.

Observations.—Morris figured a right valve, decorticated except on the auricles, and the interior of the same. He described the shell as suborbicular, oblique, and inequilateral, with numerous irregular costæ, and the auricles rather small and wrinkled. A glance at the figure will show that the latter are definitely radiate, and the costæ approximately thirty-four in number—Morris says thirty-six.

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[1] Hall—Pal. New York, 1884, V, Pt. 1, No. 1, p. xii.

[2] Non *A. limiformis*, White and Whitfield.

As to the few figures of this *Aviculopecten* hitherto published, we find as follow :—

1. *Aviculopecten (?) limæformis*, Etheridge.[1]—There is every probability that the figure of this Queensland cast represents a badly-preserved example of this species.

2. *Aviculopecten limæformis*, De Koninck,[2] we have reason to believe is not this species, as will be explained later.

3. *Aviculopecten limæformis*, Johnston,[3] we regard as Morris' species, but with a rather more rounded outline than our figure (Pl. XI, Figs. 1 and 2); it is an illustration of the more convex valve.

4. (*?*) *Aviculopecten limæformis*, Eth. fil.[4]—The figure given by one of us in all probability represents the umbo and anterior auricle of the less convex of the two valves.

5. *Aviculopecten*, c.f. *limæformis*, Waagen.[5]—A fragment of a Salt Range pectinoid fossil was so referred by Dr. W. Waagen, but we fail to trace any relation to the Australian species.

The valves of *A. limæformis* are unequal, bi-convex, but one far more convex than the other, the less convex valve becoming more or less concave towards the ventral margin. The amount of obliquity of the shell varies; it is much more marked in some individuals than in others. We find the rounded costæ to vary from thirty-four to thirty-eight in number, including some secondary ribs which are the result of interpolation and not bifurcation; these are crossed by very regular, numerous, and close-set concentric frills or laminations.

The auricles in all our specimens are defective, but, judging from Morris' figures, the cardinal margins were not long in comparison to the width of the valves, and in consequence the auricles could not have been of any great dimensions; on the other hand, in Johnston's figure, which we are at present prepared to accept as that of this species, the auricles are of

[1] Etheridge—Quart. Journ. Geol. Soc., 1872, XXVIII, p. 326, t. 14, f. 1.

[2] De Koninck—Rech. Foss. Pal. Nouv.-Galles du Sud, 1877, Pt. 3, p. 153, t. 22, f. 4.

[3] Johnston—Syst. Acc. Geol. Tas., 1888, t. 14, f. 1.

[4] Etheridge, Junr.—Geol. Pal. Q'land, &c., 1892, p. 266, t. 14, f. 1.

[5] Waagen—Rec. Geol. Survey India, 1886, XIX, p. 27, t. 1, f. 8; Salt Range Foss. (Pal. Ind.), 1901, IV, Pt. 2, p. 130, t. 5, f. 8.

fair size and rectangular, and the cardinal margin longer than one would suspect from Morris' illustration. If the figure of the Queensland specimen (by one of us) already quoted does not represent a portion of the "flat" valve, then it cannot be *D. limæformis*.

The auricles of the convex valve were costo-radiate, again judging by Morris' figure, and crossed by numerous laminæ, rendering the surface decussate.

The inequality of the valves is shown, not only by this unequal degree of convexity, but also by the projection of the umbo of the convex valve over its cardinal margin (Pl. X, Fig. 3), that of the concavo-convex, or at times almost plano-convex valve being insignificant.

One of the most important features, specifically of *D. limæformis*, is the oblique depression from the umbo downwards on one side of the convex valve (Pl. XI, Fig. 1); this possibly represents the posterior end of the valve.

The adductor impression of the "flat" valve was centrally situated, but nearer to the cardinal than the ventral margin; it appears to have been pitted for extra muscular attachments. The umbonal region also bore similar depressions for the insertion of supplementary muscles.

Localities and Horizons.—Ravensfield (*T. Brown*).—**Permo-Carboniferous—Lower Marine Series.** Bomaderry Quarry, Nowra (*F. Mitchell*); Warragamba River, near The Peaks, Burragorang; Maria Island, Tasmania; Mt. Britton Gold-field, Queensland (*R. L. Jack*).—**Permo-Carboniferous—Upper Marine Series.**

Collections.—Mining and Geological Museum, and Australian Museum.

Deltopecten illawarrensis, *Morris*, sp. (?)

(Plate II, Figs. 2 and 3.)

Pecten Illawarensis, Morris, Strzlecki's Phys. Descrip. N. S. Wales, &c., 1845, p. 277, t. 14, f. 3.

Observations.—Morris figured a portion only—about one half—of what looks like a *flat* valve, said by him to be "depressed," with sixteen prominent rounded costæ, the intercostal spaces broader than the latter, and the "ears small," but only one is shown in the figure.

It is the :—

1. *Deltopecten illawarensis*, Eth. fil.[1]—Specimens obtained at the Mount Britton Gold-field, by the Queensland Geological Survey, formed the type of the genus *Deltopecten*. The hinge-plate was observed to be broad and strong, with coarse resilium furrows and a deltoid chondrophore. The surface of some of the valves presented a ventral lateral flattening.

The limitation of *Deltopecten illawarrensis*, of all the Australian Palæopectens, has caused us the greatest trouble. If Morris' figure represents a part of a flat valve, as it appears to do, the figures of De Koninck cannot possibly represent the species, and by analogy that of Dana also, for it is morally certain that the two are identical. We are further hampered by the question of locality, as already explained under *Avicutopecten Mitchelti*, nobis. Were it not for the fact that the type is believed to be in existence, we would feel much inclined to reject the name *in toto*, as the simplest way out of a specific complication. The whole matter turns on a very simple question : What is "*Pecten Illawarensis*," Morris ?

The shell we have assumed to be this species is orbicular, bi-convex, but inequivalve, and to some extent tumid. In consequence of the imperfection of the auricles in all the specimens before us, it is difficult to distinguish the right from the left valves ; we therefore, in this case, use the terms convex and less convex valve, but we believe the former to be the left, and the latter the right valve. In the convex valve one of the slopes (anterior ?) is abrupt and steep, cutting off an apparently rectangular auricle ; a similar auricle is present in the less convex valve, but in none of our specimens are the opposite auricles of either valve preserved ; the umbo appears to have been obtusely pointed. The surface of this valve is uniformly convex from the umbo to the ventral margin, and traversed by from twenty-five to thirty-five thick, rounded, distant costæ, with here and there a smaller interpolated rib, the radii on the quadrangular (?) auricle being numerous ; the intercostal spaces are wide and flat.

In the less convex valve the surface is convex from the umbo forwards, until approaching the ventral and latero-ventral regions, when a decided flattening, or even slight concavity, sets in, like that of *D. timæformis*. The costæ are less numerous, from twenty to thirty, and more angular than in the convex valve. In both the costæ and intercostal spaces are crossed by

[1] Etheridge, Junr.—Geol. Pal. Q'land, &c., 1892, p. 269, t. 41, f. 3, t. 43, f. 2.

an immense number of close concentric frills, which also decussate the quadrangular auricle of the convex valve. Part of a broad striated hinge-plate is visible in one specimen, and a sub-deltoid chondrophore in another.

Imperfect as this description is, it is all we can ascribe to our conception of "*Pecten Illawarensis*," Morris. As previously foreshadowed, we cannot include De Koninck's figures within our synonomy, for two reasons—first, the latter do not represent an orbicular, but rather an elongately-orbicular shell; and, secondly, the costæ are not sufficiently numerous. The same remarks apply to Dana's figure also. At the same time, in justice to De Koninck, it must be admitted that his description accords far better with our conceived "*Pecten illawarensis*" than do his illustrations. The whole question of the identity of Morris' species is a very intricate one, and we do not by any means feel convinced that we have solved it satisfactorily.

Localities and Horizon.—Harper's Hill; Allandale (*C. Cullen*); Mt. Britton Gold-field, Queensland (*R. L. Jack*).—**Permo-Carboniferous—Lower Marine Series.**

Collections.—Mining and Geological Museum, and Australian Museum.

Deltopecten subquinquelineatus, *McCoy*, sq.

(Plate III, Fig. 2; Pl. IX, Figs. 1–5; Pl. XII, Figs. 2 and 3; Pl. XIII, Figs. 2 and 8; Pl. XIV, Fig. 1.)

Pecten subquinquelineatus, McCoy, Ann. Mag. Nat. Hist., 1847, XX, p. 398, t. 17, f. 1.

Observations.—McCoy's figure represents the nearly perfect left valve of what we take to be the typical form of this species—a "truncate orbicular," equilateral shell with large auricles. Variation takes place in two directions, viz., slightly in the outline, and extensively in the nature of the costæ. It is necessary to bear in mind that this typical form possessed twenty-five primary costæ, an equal number of secondary, and double the number of tertiary. The characters given below may be regarded as supplementary to those of McCoy.

It is the:—

1. *Pecten comptus*, Dana[1] (*non* McCoy[2]).—Dana describes only one valve—the convex or left. It is said to be suborbicular, with from twenty to twenty-two primary costæ, and one or two in each of the intercostal spaces; the auricles are longitudinally striate.

[1] Dana—Am. Journ. Sci., 1847, II (4), p. 160; Wilkes U. S. Explor. Exped., 1849, X (Geol.), p. 704, t. 9, f. 5.
[2] McCoy—Synop. Carb. Lime. Foss. Ireland, 1844, p. 60, t. 15, f. 14.

2. *Pecten lineatus*, Plews.[1]—The illustration is a poor copy of McCoy's figure.

3. *Aviculopecten subquinquelineatus*, De Koninck.[2]—This author described the shell as plano-convex, but mistook the right for the left valve, and consequently the nomenclature of the aurieles; on the other hand, he correctly indicated the relative differences between the umbos of the two valves. His figure represents a poor cast of the left valve, which we certainly would not have recognised had it not been for the description. De Koninck describes twenty-five primary costæ inequidistant from one another and a variable number of subsidiary ribs.

4. *Aviculopecten subquinquelineatus*, Eth. fil.[3]—A left valve was described from the Bowen River Coal-field. The primary costæ and radiate aurieles are shown in the figure.

5. *Aviculopecten hiemalis* (Salter), Diener.[4]—We have not access to Salter's original figure, but Dr. Diener's is suspiciously like some varieties of *A. subquinquelineatus*, especially in the costation, and the valves are said to be markedly unequal. At the same time, the shell is rather too much expanded laterally, the lateral angles extending too far beyond the aurieles.

From our specimens we gather the following additional particulars. The valves are semi-plano-convex, the right valve flat, or nearly so, the left convex. The right anterior auriele is smaller than the left anterior, in that the lower margin is straight, leaving a sharp and deep byssal sinus between it and the body of the valve; the posterior aurieles of both valves are similar to one another. The anterior and posterior slopes of the left valve are steeply inclined, and the umbo of the right valve smaller and blunter than that of the left. The hinge-plates extend the whole length of the dorsal margin, are densely grooved with fine resilium furrows, and are obliquely inclined to the general plane of the valves, leaving between them a deep transverse gape, occupied during life by the resilium. Below the umbo of the right valve is visible a very large semicircular and deeply concave chondrophore, concentrically furrowed by a continuation of the resilium furrows (Pl. XIV, Fig. 1).

[1] Plews—Mining Inst. Journ., 1858, VI, Pt. 3, p. 4, 3rd fig. from left, top row.

[2] De Koninck—Rech. Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 152, t. 22, f. 2.

[3] Etheridge, Junr.—Proc. R. Phys. Soc. Edinb., 1880, V, p. 207, t. 15, f. 52.

[4] Diener—Himalayan Fossils (Pal. Ind.), 1897, I, Pt. 4, p. 9, t. 5, f. 10 a and b, 11.

The following are the variations exhibited by the costæ, other than that described by McCoy :—

(*a*) The absence of tertiary costæ.

(*b*) Two tertiary costæ between two primary to the exclusion of secondary.

(*c*) Two tertiary costæ on each side of a secondary.

We have only seen indifferent examples of the right valve, but the costæ appear to be much simpler than in the left—there is a less marked separation into primary, secondary, and tertiary. In one specimen the primary costæ show traces of bifurcation, but not so the others. McCoy's figure does not represent a full grown individual; we possess much larger examples.

Localities and Horizon.—Portion 52, Parish Hawkins, County Phillip (*C. E. Murton*); Creek, one and a half mile south-west of Dapto (*C. Cullen*); near Cessnock (*C. Cullen*); Black Head, Gerringong (*W. S. Dun, B. G. Engelhardt*); Albion Park Road, Jamberoo (*B. G. Engelhardt*); Wollongong (*C. Cullen*); Ravensfield (*T. W. E. David*); Bundanoon (*C. Cullen*); Farley (*J. Waterhouse*); Gerringong (*R. Etheridge, W. S. Dun*); Rutherford's Quarry, W. Maitland; Lochinvar; Portion 110, Parish Wingen, County Brisbane (*C. Cullen*); half a mile south-east of Red Rock, Drake (*C. S. Wilkinson*).—**Permo-Carboniferous—Lower and Upper Marine Series.**

Collections.—Mining and Geological Museum, and Australian Museum.

Deltopecten leniusculus, *Dana.*

(Plate III, Fig. 1; Pl. IV; Pl. VI, Fig. 1; Pl. VII, Figs. 1 and 2; Pl. X, Figs. 1 and 2; Pl. XI, Fig. 3.)

Pecten leniusculus, Dana, Am. Journ. Sci., 1847, IV, p. 160.

,, ,, Dana, Wilkes U. S. Explor. Exped., 1849, X (Geol.), p. 704, Atlas, t. 9, f. 6 a and b.

Observations.—Dana figured both the convex and flat valves, with rectangular auricles, but the latter do not appear to be perfect.

There is only one other figure of this species extant, so far as we know :—

1. *Aviculopecten leniusculus*, De Koninck,[1] a convex valve devoid of the auricles.

[1] De Koninck—Rech. Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 151, t. 21, f. 3.

To Dana's description of *D. leniusculus*, it may be added that the plano-convex valves are orbicular in outline, with a general tumid or obese appearance, and almost equal auricles in both valves. In the convex or left valve, the anterior auricle is long and triangular, with a well marked depression separating it from the valve surface, and it is highly costo-radiate. Under the wing-like posterior auricle of the same valve is a shallow emargination, but the outer margin is rounded. The valve was decorated with a great number of delicate striæ-like costæ and strong distant latilaminæ; the test was thick. The auricles of the right or flatter valves are similar to those of the convex valve, except that a byssal sinus is present between the left auricle and body of the valve. Both auricles in this valve are costo-radiate, and bear well marked latilaminæ (Pl. XI, Fig. 3).

The adductor scar in the right valve is transversely oval, subcentral (dorso-posterior) in position, and supplementary umbonal muscle fibre pits are present. These may be distinguished in Pl. VII, Fig. 2, as light spots in a semicircle below the chondrophoral depression.

The form and delicate striæ-like costæ are typical features of this species, which appears to have been abundant in our Permo-Carboniferous Series.

Localities and Horizon.—Gerringong (*W. S. Dun*); Mt. Vincent (*J. Waterhouse*); near Dee's Hotel, West Maitland (*W. S. Dun*); Wollongong (*C. Cullen*); Nowra (*C. Cullen*).—**Permo-Carboniferous—Upper Marine Series.**

Collections.—Mining and Geological Museum, and Australian Museum.

Deltopecten farleyensis, *sp. nov.*

(Plate VI, Fig. 2; Pl. XIII, Figs. 4–6; Pl. XVI, Fig. 4.)

Specific Characters.—Shell broadly fan-shaped, or broadly triangular, both valves practically flat. Dorsal margins as wide, if not wider than the bodies of the valves; umbo of the right valve sharp, that of the left depressed; anterior and posterior slopes in both diverging rapidly and widely from the umbos. Anterior auricles elongately triangular, with the outer margins obliquely rounded, a narrow, deep, byssal sinus separating the auricle in the right from the body of the valve; posterior auricles alate, with an open emarginate outer edge, and the posterior dorsal angles pointed. Both

the bodies of the valves and aurieles are decorated by a large number of fine radiating costæ, with smaller ribs intercalated, and crossed by regular concentric latilaminæ. Hinge-plates very long and linear with several resilium furrows, and a wide shallow chondrophore in the left valves.

Observations.—Deltopecten farleyensis is a very distinct species owing to its widely triangular or broadly fan-shaped outline, and great length of the dorsal margin; it must have been a thin and delicate shell. Amongst our Australian Palæopectens it stands alone and has no near ally, and is altogether a striking-looking form. Both valves appear to all intents and purposes to have been flat, or at any rate very slightly convex. In its fine and very numerous linear costæ *D. farleyensis* resembles *D. leniusculus.*

Localities and Horizon.—Rutherford, near Farley (*W. S. Dun*); three hundred yards west of Farley Railway Station (*T. W. E. David*); Clift's Paddock, Lochinvar (*T. W. E. David*); near Golden Age Mine, Boorook (*E. C. Andrews*); Pokolbin (*C. A. Süssmilch*).—**Permo-Carboniferous —Lower Marine Series.**

Collections.—Mining and Geological Museum; Geological Dept., Technical College.

Deltopecten Fittoni, *Morris*, sp.

(Plate VIII, Figs. 1-3; Pl. X, Fig. 6; Pl. XVI, Fig. 1.)

Pecten Fittoni, Morris, Strzelecki's Phys. Descrip. N. S. Wales, &c., 1845, p. 277, t. 14, f. 2.

Observations.—Morris figured a nearly complete left valve, but apparently with the test incomplete. It is the :—

1. *Aviculopecten Fittoni,* De Koninck.[1]—This author gave two figures, one a copy of the type figure, the other an internal cast of apparently the right valve. No other figures are extant that we know of.

We have before us both right and left valves. The orbicular shell is bi-convex, the valves equal and tumid, some specimens having a dumpy or squat appearance. The dorsal margins are less in width than the valves, the lateral and ventral margins combined almost forming a semicircle, the outlines on the anterior and posterior sides being well-rounded and rather projecting; the umbos are fairly acute. The anterior aurieles are by no means large in proportion to the size of the valves, somewhat flattened, with rounded outer margins, and shallow open emarginations. The posterior ears are also

[1] De Koninck—Rech. Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 162, t. 21, f. 4, 4a.

comparatively small, flattened, and apparently rectangular. Morris speaks of fifteen rounded costæ, but the costæ range up to twenty-five, all simple, widely separated, prominent and depressed convex; the intercostal spaces are equally wide in casts, and concave. The whole, both costæ and intercostal spaces, are traversed by supplementary, fine, very numerous radii, so regular that they cannot be described as rendering the costæ fasciculate. Morris says these radii are granular; those of one of our own specimens may be so, but the state of preservation is not sufficiently clear to enable us to unquestionably corroborate this. He also states that the "furrows" are each divided by a fine ridge, but these are indistinguishable from the other radii. The hinge-plates are linear, although well-marked, and the chondrophores longitudinally deltoid.

In two specimens (Pl. VIII, Figs. 2 and 3) that we cannot otherwise distinguish from this species, a posterior obliquity is to be noticed, but we do not consider this alone as invalidating a reference of them to *D. Fittoni*.

Localities and Horizons.—Dapto (*C. Cullen*); Dagworth, West Maitland (*J. Waterhouse*).—**Permo-Carboniferous—Upper Marine Series.** Ravensfield (*J. Waterhouse, T. W. E. David, C. Cullen*); Harper's Hill (*T. W. E. David*).—**Permo-Carboniferous—Lower Marine Series.**

Collections.—Mining and Geological Museum, and Australian Museum.

Deltopecten wingenensis, *sp. nov.*

(Plate XIV, Figs. 2–4.)

Specific Characters.—Shell (cast) sub-oblong and slightly oblique towards the anterior; length exceeding the width; valves plano-convex; cardinal margins less than the width of the valves. Left valve convex, with the lateral and ventral margins rounded, the anterior lateral above slightly emarginate, below somewhat produced; umbo pointed; anterior auricle flattened, apparently rectangular; posterior auricle not larger than the anterior, flattened and pointed, its outer edge emarginate. Right valve flat; umbo inconspicuous; anterior auricle flat, rectangular, divided off by a deep sulcus. Sculpture of the left valve consisting of from eight to ten strong, rounded, primary costæ, with a smaller secondary rib between each pair of the former; in the right valve are numerous fine close riblets, apparently of one order. Hinge-plates narrow, with a semicircular chondrophore on each.

Observations.—This species bears a general resemblance to *Aviculopecten Hardmani*, Eth. fil.,[1] but we believe it to be distinct from this North Australian form. There is here no sign of echination on the costæ of *D. wingenensis*, which is quite distinct from any other New South Wales *Deltopecten*.

Locality and Horizon.—Portion 110, Parish Wingen, County Brisbane (*C. Cullen*).—**Permo-Carboniferous—Upper Marine Series.**

Collection.—Mining and Geological Museum.

Deltopecten obliquatus, *sp. nov.*

(Plate XIII, Fig. 7.)

Specific Characters.—Shell (cast) obliquely and unsymmetrically oval, produced posteriorly. Left valve moderately convex; dorsal margin considerably shorter than the width of the valve; umbo acute; anterior slope abrupt, but a gently graduated posterior slope; anterior auricle large, flat, triangular, the outer margin obliquely rounded, emarginate at its junction with the valve; posterior auricle moderately large, wing-like (outer margin not preserved). Sculpture consisting of primary, secondary, and tertiary costæ, obliquely curved on the posterior side; a secondary costa exists between every two primary, and a tertiary on each side the former, but apparently very short; traces of both latilaminæ and transverse concentric lines are apparent. Hinge-plate linear, grooved with resilium furrows, chondrophore small.

Observations.—This is a very marked form, quite distinct from any other Australian species. Only the left valve is known, in the cast condition, the auricles in this state being unornamented. The outline indicates an approach to those forms termed by the late Prof. James Hall *Pterinopecten*.

Locality and Horizon.—Porter's Bay, Tasmania.—**Permo-Carboniferous.**

Collection.—Mining and Geological Museum.

[1] Etheridge, Junr.—Contrib. Pal. S. Austr., No. 9 (*S. Austr. Parl. Papers*, 1897, No. 127), p. 15, t. 1, f. 4–8.

Deltopecten, *sp.*

(Plate IX, Fig. 12)

Observations.—For the purpose of future identification we figure an internal cast that we are unable to place in any of the foregoing species of the genus.

The valve was moderately convex, with a short cardinal margin, a fairly wide hinge-plate, bearing coarse resilium furrows and a deltoid chondrophore. The cast of the umbo is pointed and narrow, but does not overtop the cardinal margin. The auricles are imperfect, but one is certainly flat and rectangular. No trace of external sculpture remains, but there is clear evidence of at least three widely-spaced flattened latilaminæ.

We regret we are unable to identify this cast, for geologically speaking, it is of importance as the only Pectinoid shell yet met with in the Tokal Conglomerate.

Locality and Horizon.—Tokal, Paterson (*T. W. E. David*).—**Permo-Carboniferous—Lower Marine Series.**

Collection.—Mining and Geological Museum.

Family—PECTINIDÆ.

Genus—ENTOLIUM, *Meek*, 1865.

Entolium, Meek, Progress Report Geol. Survey California, 1865, I, App. B, p. 478 (American Mesozoic type—*E. aurarium*, Meek[1]).

,, Meek, Hayden's Final Report U. S. Geol. Survey Nebraska, Pt. 2, 1872, p. (American Palæozoic type—*Pecten aviculatus*, Swallow[2]).

Observations.—The late Prof. James Hall believed *Entolium* to be in great part a synonym of *Pernopecten*, Winchell, but the relation of the two genera is an intricate one, and the explanation offered[3] by the great American

[1] *The actual type* selected by Meek for his subgenus *Entolium* was the European Jurassic *Pecten demissus*, Phill. The general question is, unfortunately, still further complicated by Prof. A. E. Verrill selecting this shell as the type of his genus *Protamussium* (Trans. Connecticut Acad. Arts and Sci., 1899, X, Pt. 1, p. 71). He appears to have overlooked Meek's previous selection.

[2] European Palæozoic type is *Pecten Sowerbyi*, McCoy.

[3] Hall.—Pal. N. York, 1885, V, Pt. 2, p. lvii.

Palæontologist is anything but satisfactory. It appears to us, after carefully reading Professor Hall's remarks and such of the literature as we have access to, that the identity of the two names is by no means conclusively proved even now. Mr. G. W. Tryon, Junr., also referred[1] *Entolium* to *Pernopecten*, but without comment. It is not within our power to contribute any observations of moment to the subject, but in the meantime we adopt *Entolium* for a New South Wales shell, after the type of *Pecten aviculatus*, Swallow, and *P. Sowerbyi*, McCoy. We are supported in this by the fact of the late Prof. E. A. Verrill, in his "Study of the Family Pectinidæ," &c., recognising[2] both *Pernopecten* and *Entolium* as valid—typifying the former by *Pecten timiformis*, White and Winchell,[3] and the latter by *P. cornutum*, Quenstedt.

Dr. Wheelton Hind has recently referred *Entolium* to another genus of Meek's—*Syncyclonema*, a Cretaceous Pectinoid shell—with the following remark[4]:—"Unfortunately no one recognised that the genus [*Entolium*] occurred also in the Cretaceous beds, and had been described by Meek in 1864 as *Syncyclonema*, and, therefore, this generic term has the priority to *Entolium*."

We fail to appreciate this passage, as from our reading of the original descriptions of Meek's two American type species of *Entolium*, and that of *Syncyclonema*, we are unable to see any valid reasons for uniting the two names in one—unless Dr. Hind is in possession of more recent information. Prof. Verrill's remarks appear to strengthen our view.

Dr. Hind is not the first to suggest a union of *Entolium* and *Syncyclonema*, for we find Mr. Henry Woods in the previous year writing as follows[5]:—"*Syncyclonema* should probably be united with *Entolium*, as has been suggested by Philippi." The internal structure shown in one of his figures of *Pecten orbicularis*, Sby.,[6] of the Lower and Upper Cretaceous, certainly coincides in a great measure with that of *Entolium;* but can it be also proved that the internal structure of Hall and Meek's type of *Syncyclonema*, viz., *Pecten rigida*, was the same? If so, then *Entolium* and

[1] Tryon, Junr.—Str. and Syst. Couch., 1884, III, p. 291.
[2] Verrill.—Trans. Connecticut Acad. Arts and Sci., 1899, X, pt. 1, pp. 62 and 63.
[3] Non *Pecten limæformis*, Morris.
[4] Hind.—Mon. Brit. Carb. Lamellibr., 1903, II, Pt. 2, p. 117.
[5] Woods.—Mon. Cret. Lamellibr. England, 1902, Pt. 4, p. 145.
[6] Woods.—*Loc. cit.*, t. 27, f. 14.

Syncyclonema are identical; if not, there is not the slightest ground for uniting them. In the latter case, the whole matter appears to us to be the adoption of a previously made suggestion by Woods, and an assumption by Hind.

For the purposes of this inquiry we have looked up every reference we can find relating to American *Syncyclonemæ*, and in not one single instance is any cardinal structure similar to that of Woods' figure of the interior of *P. orbicularis*, Sby., either described or figured. We have compared Meek's original definition[1] of *Syncyclonema*, with *Pecten rigida* as its type; the same Author's subsequent remarks[2] on the species; the description of the shell so referred by Whitfield[3]; Whiteaves' description[4] of *Syncyclonema meekiana*, and Conrad's *S. simplicia*.[5] Moreover, if *S. rigida*, Whitfield, the interior of which is figured, be *S. rigida*, Hall and Meek, the two genera are most certainly not identical.

Even previous to Mr. Woods' suggestion, *Syncyclonema* was united to another genus—*Pseudamussium*—by Mr. G. W. Tryon, Junr.,[6] but without comment.

As to Mr. E. Philippi's remarks, which appear to have been the ground for recording the identity of the two genera in question, the only remark of importance we can find in his paper "Zur Stammesgeschichte des Pectiniden" is the following passage:—After referring to the near relationship of *Entolium* and *Amnssium*, he says: "In *Pecten discites* (Schlotheim, sp., a Triassic form), moreover, a character manifests itself which is peculiar to the collective Jurassic Entoliums, but is particularly strongly shown in the Chalk Entoliums, and led Meek to suggest and describe the subgenus *Syncyclonema*, which, as I will later seek to prove, must be merged in Entolium"[7]; this we have not been able to find. So far as we understand Philippi, the feature that appears to have struck him is the concentric sculpture, for, on defining *Entolium* on a previous page (p. 70), he says: "Smooth, very rarely with fine radii, often with concentric sculpture (*Syncyclonema*)."

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[1] Meek—Smithsonian Miscel. Collns., 1864, No. 177, p. 31.
[2] Meek—Report U. S. Geol. Survey Territories (Hayden's), 1876, IX, p. 27, t. 16, f. 5 *a* and *b*.
[3] Whitfield—Pal. Black Hills Dakota, 1880, p 383, t. 7, f. 1.
[4] Whiteaves—Canadian Mes. Foss. 1876, I, Pt. 1, p. 82, f. 9.
[5] Conrad—Am. Journ. Conch., 1859, V, Pt. 2, p. 99, t. 9, f. 20.
Tryon, Junr.—Str. and Syst. Conch., 1884, III, p. 290.
[7] Philippi—Zeitsch. Deuts. Geol. Gesellsch., 1900, LII, Heft 1, p. 80.

Dr. Hind further says no one has recognised the presence of *Entolium* in Cretaceous rocks. Mr. C. B. Boyle's Catalogue and Bibliography of North American Mesozoic Invertebrata[1] records on p. 119, as follows:—

"ENTOLIUM n. sub-gen. Meek. (1865)."

By again referring to p. 37, under *Amussium*, of which Meek constituted *Entolium* a subgenus, the American Mesozoic type referred to thus:—

"AMUSSIUM AURARIUM n.s. Meek. (1865).

. . . . . Formation: Jurassic [Cretaceous ?]."

Mr. E. Philippi also refers several times to the existence of Cretaceous Entoliums.

ENTOLIUM AVICULATUM, *Swallow*, sp. (?).

(Plate XV, Figs. 1–4.)

Entolium aviculatum (Swallow), Meek, Hayden's Final Report U. S. Geol. Survey Nebraska, Pt. 2, 1872, p. 189, t. 9, f. 11 *a-f.*

Entolium, sp., Eth, fil., Rec. Geol. Survey N. S. Wales, 1894, IV, Pt. 1, p. 35, t. 7, f. 15.

Observations.—Our specimens exhibit the following characters:—Shell suborbicular, lenticular, compressed, subequivalve; cardinal margins very short, straight in the right valve, concave or emarginate in the left; umbos small, acute, and from them in a downward direction the anterior and posterior lateral margins are straight, or a trifle concave for slightly less than one-third the length of the valves, then they become well rounded, and in conjunction with the ventral margins form nearly a semicircle; auricles small, in the left valve connate-rectangular, elevated, in the right rectangular simply, but in both valves externally separated from the general surface by impressed lines. From the umbo in each valve diverge two faint linear impressions, reaching nearly to the anterior and posterior lateral margins. Sculpture of remarkably close, delicate, concentric lines, with traces of equally fine radii; V-sculpture not observed.

[1] Boyle—Bull. U. S. Geol. Survey, No. 102, 1893.

On the surface of internal casts we observe the impressions of the umbonal divergent ridges, the short "auricular crurae,"[1] but the chondrophores and "auricular tubercles"[2] are preserved in neither valve, nor the transverse auricle furrows of the left valve. There is no trace whatever of cardinal crenulations or resilifers.

We are quite unable to separate these shells from *Entolium aviculatum*, Swallow, sp., as figured by Meek. Any attempt to unravel the intricate synonomy of this species is beyond us, and, without a complete suite of American and European specimens of *Pernopecten* and *Entolium*, such an attempt would be both futile and unprofitable. We may remark, however, that we believe time and investigation will prove some, at least, of the shells described by one of us as *Pecten* or *Entolium Sowerbyi*, McCoy[3] (*non* Nyst), if not the species in chief also, to be identical with *E. aviculatum*. The trivial features of stronger concentric markings, auricles more pointed or elevated, suggested by Mr. Meek as a means of separation between *Entolium Sowerbyi* and *E. aviculatum*, can hardly be looked upon as more than varietal. Even in *E. Sowerbyi* itself much variation exists in these characters.

The forms previously referred to *Entolium Sowerbyi*, and possibly identical with *E. aviculatum*, are:—*P.* (*Amussium*) *Sowerbyi*, Eth. fil.,[4] and *Entolium Sowerbyi*, Eth. fil.[5]

In the event of the American and British shells, as here indicated, proving identical, McCoy's name undoubtedly has precedence, but Nyst[6] described a *Pecten Sowerbyi* anterior to McCoy, and under strict nomenclature rules that of the latter author becomes a synonym. To avoid any complication in such a contingency, we think it will be better to adopt D'Orbigny's name of *Pecten bathus*[7] following Professor de Koninck's lead.[8]

It is also within the range of possibility that *Pecten valdaicus*, Keys. and de Vern.,[9] and other figures of *Pecten Sowerbyi*[10] by one of us, may be

[1] Verrill—Trans. Connecticut Acad. Arts & Sci., 1899, X, Pt. 1, p. 51.
[2] Verrill—*Ibid.*
[3] McCoy—Synop. Carb. Lime. Foss. Ireland, 1844, p. 100.
[4] Etheridge, Junr.—Geol. Mag., 1877, IV (2), t. 12, f. 1-3.
[5] Etheridge, Junr.—Ann. Mag. Nat. Hist., 1878, II (5), t. 1, f. 3-5.
[6] Nyst—Descrip. Coqu. Polyp. Foss. Terr. Tert. Belgique, 1843, p. 293.
[7] D'Orbigny—Prod. Pal., 1850, I, p. 139.
[8] De Koninck—Rech. Anim. Foss. Carb. Bleiberg, 1873, p. 94.
[9] Keyserling and De Verneuil—Murchison's Geol. Russia in Europe, 1845, II, p. 328, t. 27, f. 9.
[10] Etheridge, Junr.—Geol. Mag., 1874, I (2), t. 13, f. 1-2

referable to a distinct species on account of their larger size, more expanded form, and shorter anterior and posterior lateral margins divergent from the umbos.

The Belgian forms of the genus illustrated by Professor de Koninck,[1] aided by Dr. Julien Fraipont, are peculiar, and will require very careful comparison with the entire suite of British and American species.

The occurrence of an *Entolium* in the Carboniferous rocks of New South Wales is a fact of great interest, adding to its already known wide geographical distribution—Britain, Belgium, Carinthia, Eastern Russia, and North America.

Localities and Horizon.—Somerton; West of Mt. Uriari, Somerton (*C. Cullen*); Dungog Road, nineteen miles from West Maitland (*J. Waterhouse*); Portion 7, Parish Goonoo Goonoo, County Parry (*G. A. Stonier*); Glen William Road, two and a half miles from Clarence Town (*C. Cullen*).—**Carboniferous.**

Collection.—Mining and Geological Museum.

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[1] De Koninck and Fraipont—Faune Calc. Carb. Belgique, Pt. 5, 1885, pp. 241-243.

III.—TABLE SHOWING THE STRATIGRAPHICAL AND GENERAL GEOGRAPHICAL DISTRIBUTION OF AUSTRALIAN PALEOPECTENS AS DEDUCED FROM ACTUAL OR FIGURED SPECIMENS KNOWN TO THE AUTHORS.

Genus and Species.	Permo-Carboniferous.								Carboniferous.
	Northern Coal-field.		Southern Coal-field.	Western Coal-field.	New England.	Tasmania.	Queensland.	W. Austr.	
	Lower Marine.	Upper Marine.							
Aviculopecten Engelhardti ...	×	×	...	...	...	...	...	...	.....
,, Mitchelli	×	?	...	...	...	...	...	...	.....
,, ponderosus ...	.....	×	...	...	...	...	...	...	.....
,, profundus ...	×	.....	...	...	...	...	...	...	.....
,, ptychotis	.....	.....	...	...	...	...	...	...	×
,, squamuliferus ...	×	.....	...	...	...	×	...	...	.....
,, Sprenti ...	×	.....	...	×	...	×	...	...	.....
,, tenuicollis ...	×	.....	...	...	...	...	...	×	.....
,, tessellatus ...	.....	.....	...	...	...	...	...	...	×
,, spp. ind.	.....	.....	...	...	...	...	...	...	×
Deltopecten farleyensis	×	.....	...	...	×	...	...	...	.....
,, Fittoni	×	×	×	...	...	...	...	...	.....
,, illawarrensis ...	×	.....	...	...	...	...	×	...	.....
,, leniusculus	.....	×	×	...	...	...	...	...	.....
,, limæformis	×	?	...	...	...	×	...	...	.....
,, obliquatus	.....	.....	...	...	...	×	...	...	.....
,, wingenensis ...	.....	×	...	...	...	...	...	...	.....
,, subquinquelineatus ...	×	×	×	...	×	...	...	×	.....
,, sp. ind.	×	.....	...	...	...	...	...	...	.....
Entolium aviculatum	.....	.....	...	...	...	...	...	...	×

PLATES AND EXPLANATIONS.

Plates I–XII and XVI were prepared direct from the specimens by Mr. A. E. Dyer, at the Government Printing Office, Sydney. Plates XIII, XIV, and XV were drawn by Mr. F. R. Leggatt.

Unless otherwise stated to the contrary, the figures are all of the natural size.

PLATE I.

Aviculopecten Mitchelli, *Eth. fil. and Dun.*

Fig. 1. Left or most convex valve, testiferous in part, less the posterior auricle, and showing costæ and concentric frills.

Fig. 2. Right or nearly flat valve, showing similar characters and a costate anterior auricle.

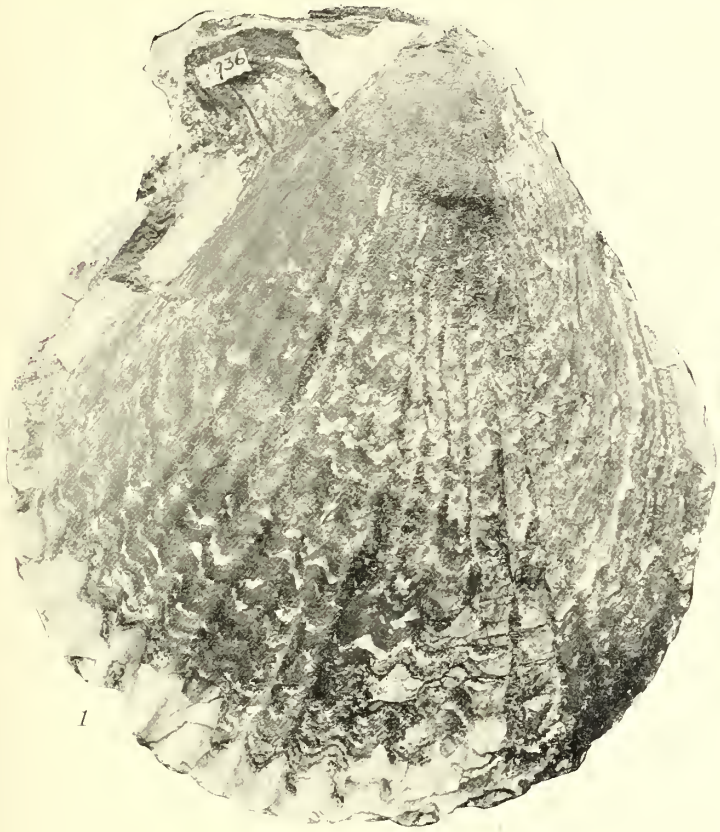
Fig. 3. Another example of a left valve, partly testiferous, with portions of both auricles, &c.

Aviculopecten squamuliferus, *Morris*, sp.

Fig. 4. External impression of a right valve taken from a relief, exhibiting the numerous costæ and close imbricating concentric frills on the general body of the valve, and decussated auricles, the radiating costæ being the stronger.

Localities.

Figs. 1–3 Road cutting, near Allandale Railway Station.
Fig. 4. Farley.



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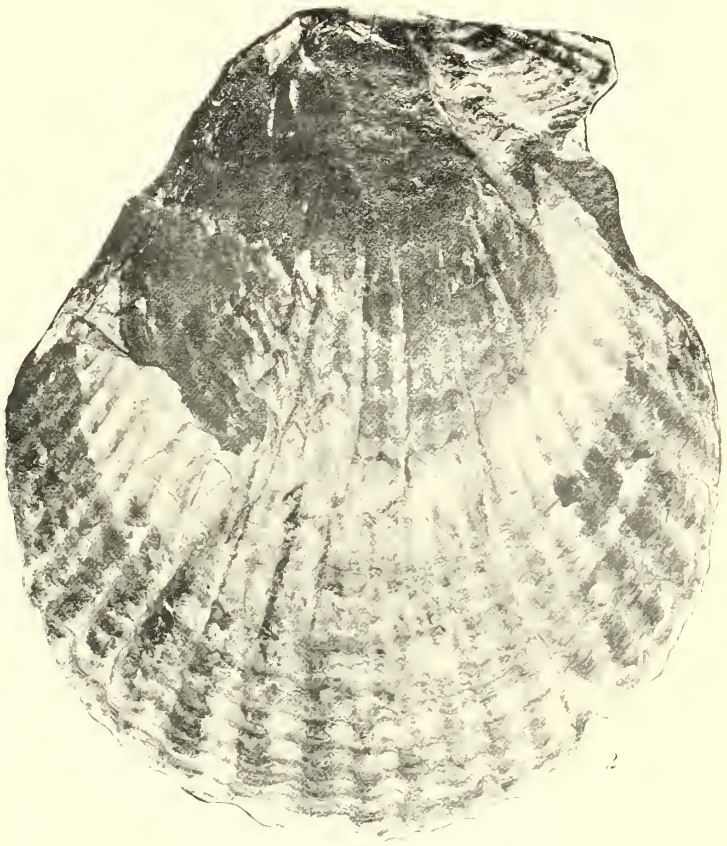

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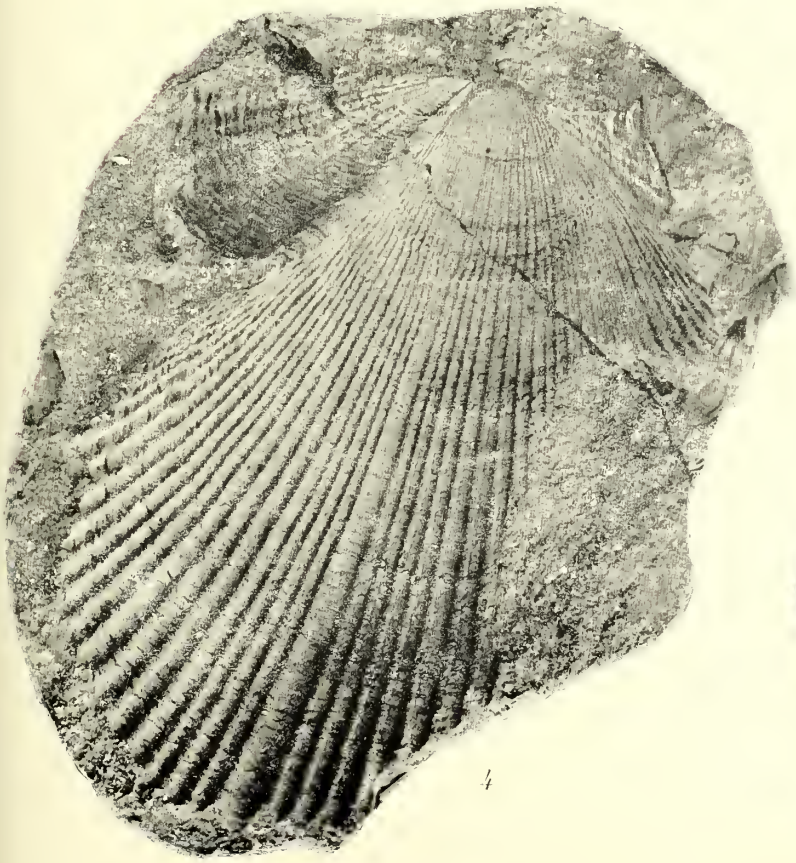

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PLATE II.

Aviculopecten Mitchelli, *Eth. fil. and Dun.*

Fig. 1. Left valve, as in Plate I, Figs. 1 and 3.

Deltopecten illawarrensis, *Morris*, sp.

Fig. 2. More or less testiferous convex valve, with coarse rounded costæ, and close concentric frills; portion of one auricle, costo-radiate, is also preserved.

Fig. 3. Partly testiferous less convex valve, but in a more decorticated condition than Fig. 2, and the costæ sharper.

Aviculopecten squamuliferus, *Morris*, sp.

Fig. 4. External impression of a right valve of a younger individual than that represented in Plate I, Fig. 4, taken from a relief.

Fig. 5. Internal cast of a right valve.

Aviculopecten Sprenti, *Johnston*.

Fig. 6. Internal cast of a left valve, with primary and secondary costæ only, and the auricles slightly imperfect.

Fig. 7. External impression of a left valve taken from a relief, exhibiting spined primary, secondary, and tertiary costæ, almost perfect auricles similarly spined, and a line of spine bases along the cardinal margin; the lateral extension of the posterior auricle is to be noted.

Localities.

Fig. 1. Harper's Hill, near Allandale.
Figs. 2, 3. Road cutting, near Allandale Railway Station.
Fig. 4. Ravensfield.
Fig. 5. Farley.
Fig. 6. Farley.
Fig. 7. Lochinvar.

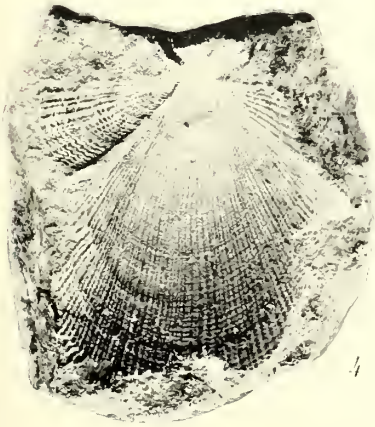
1

2

3

6

7



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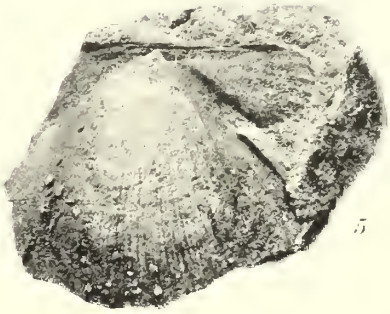

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PLATE III.

Deltopecten leniusculus, *Dana*, sp.

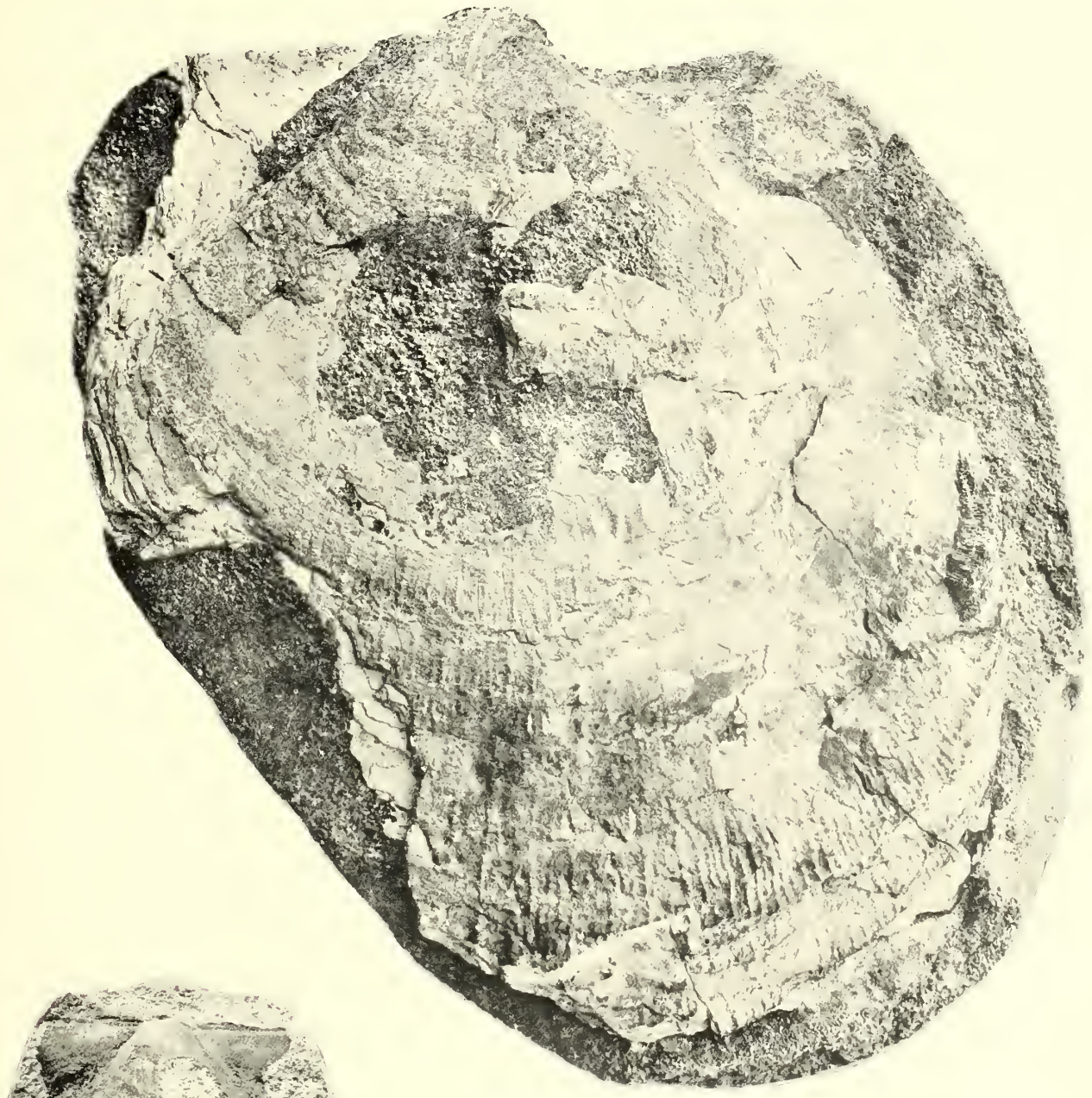
Fig. 1. A very old and partially exfoliated testiferous left valve.

Deltopecten subquinquelineatus, *McCoy*, sp.

Fig. 2. Internal cast of a somewhat oblique left valve.

Localities.

Fig. 1. Gerringong.
Fig. 2. Lochinvar.



1

2

PLATE IV.

Deltopecten leniusculus, *Dana*, sp.

Internal cast of a large left valve, exhibiting the cast of the chondrophore. The outline of the posterior auricle is not perfect.

Locality.

West Maitland.

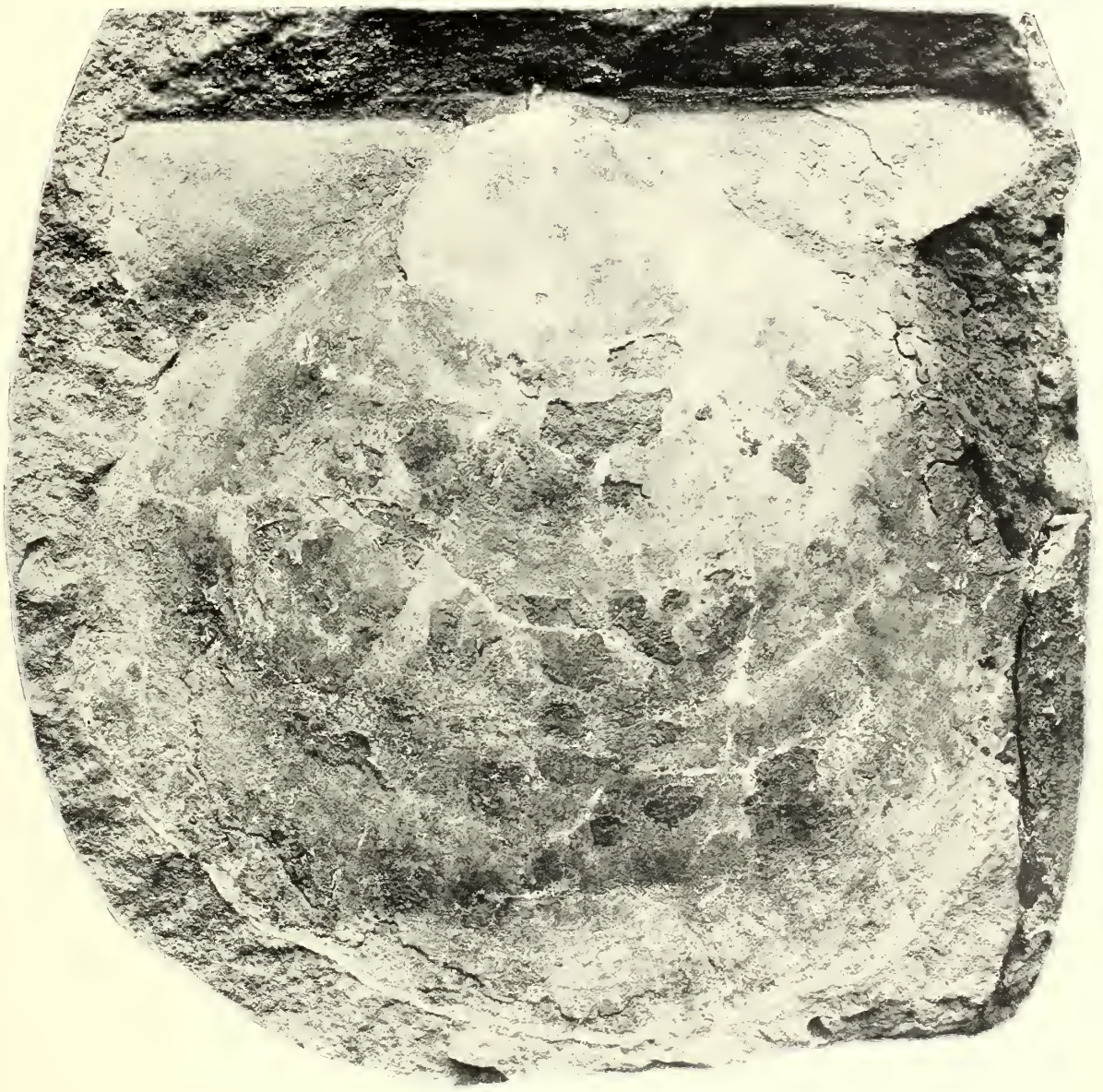


PLATE V.

Aviculopecten ponderosus, *Eth. fil. and Dun.*

Exfoliated testiferous convex valve ; a portion of one auricle is preserved.

Locality.

Portion 97, Parish Milfield, County Northumberland.

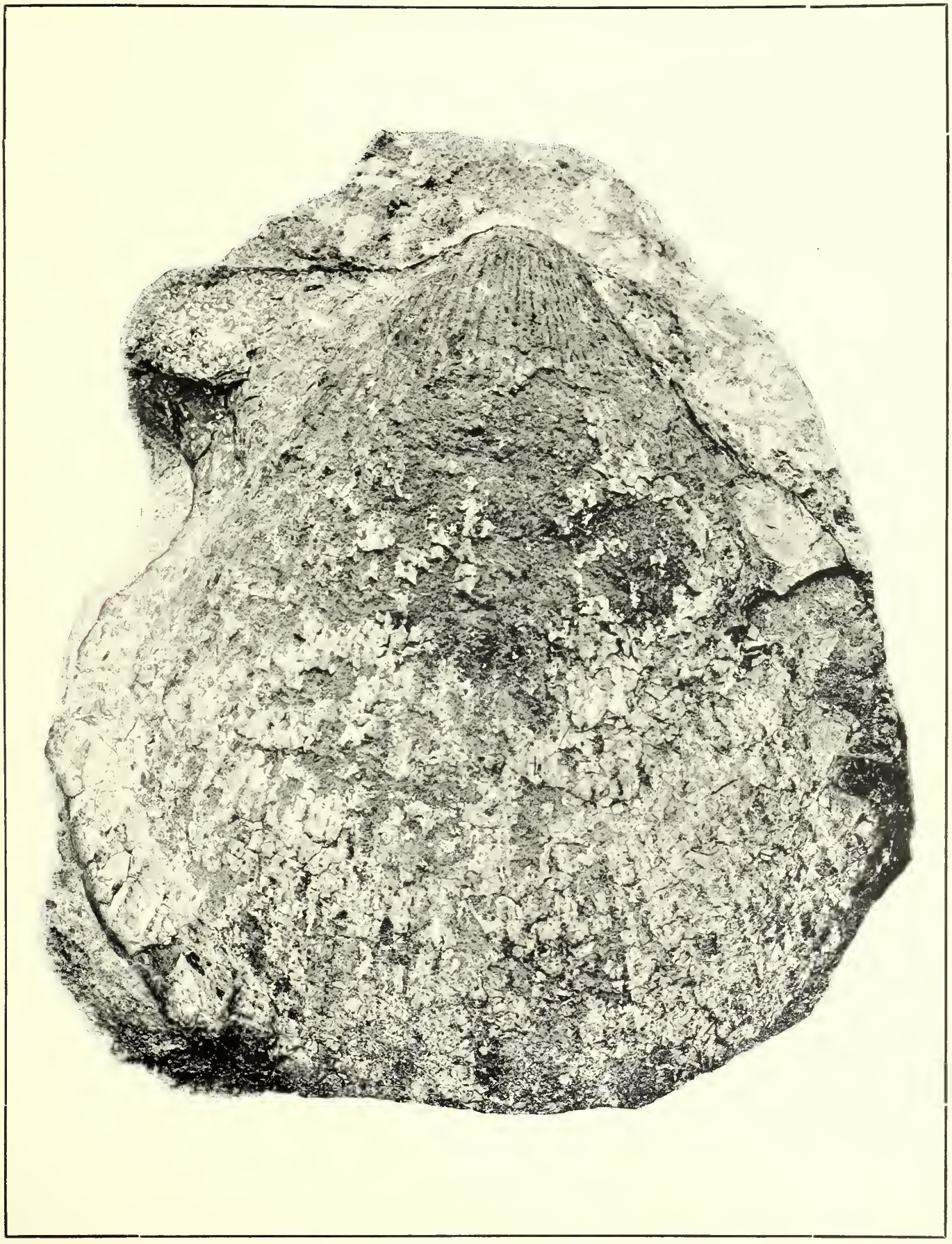


PLATE VI.

Deltopecten leniusculus, *Dana*, sp.

Fig. 1. Greatly exfoliated left valve, indicating a considerable thickness of test.

Deltopecten farleyensis, *Eth. fil. and Dun.*

Fig. 2. Compressed testiferous right valve, showing very numerous linear costæ and wide latilaminæ, both on the body of the valve and the auricles.

Localities.

Fig. 1. Mt. Vincent.

Fig. 2. New England—probably near Drake.

1
2

PLATE VII.

Deltopecten leniusculus, *Dana*, sp.

Fig. 1. External impression of a right valve, exhibiting the very large number of linear costæ, and costate auricles.

Fig. 2. Internal cast of the united valves. Above is the left or most convex valve, below the right or less (practically flat) valve. In the centre of the cardinal margin of the latter is the cast of the chondrophore, and below it the impressions of three supplementary muscular attachments.

Localities.

Fig. 1. Nowra.

Fig. 2. West Maitland.

1

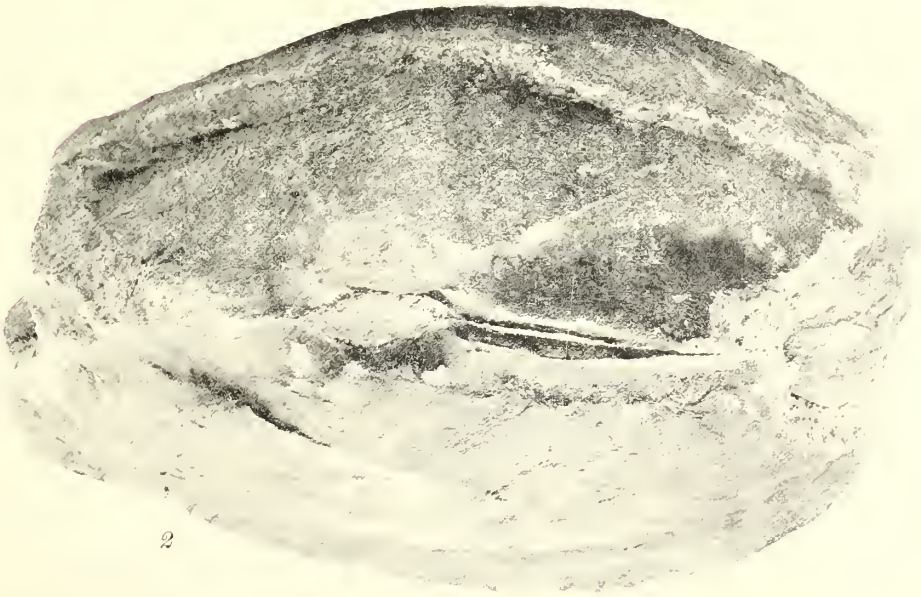


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PLATE VIII.

Deltopecten Fittoni, *Morris*, sp.

Fig. 1. Partially testiferous left valve. Careful inspection of this figure will reveal the obtusely rounded major costæ traversed by the linear costæ, which cover the whole of the valve.

Fig. 2. Internal cast of a left valve, slightly distorted; the major costæ only are here visible.

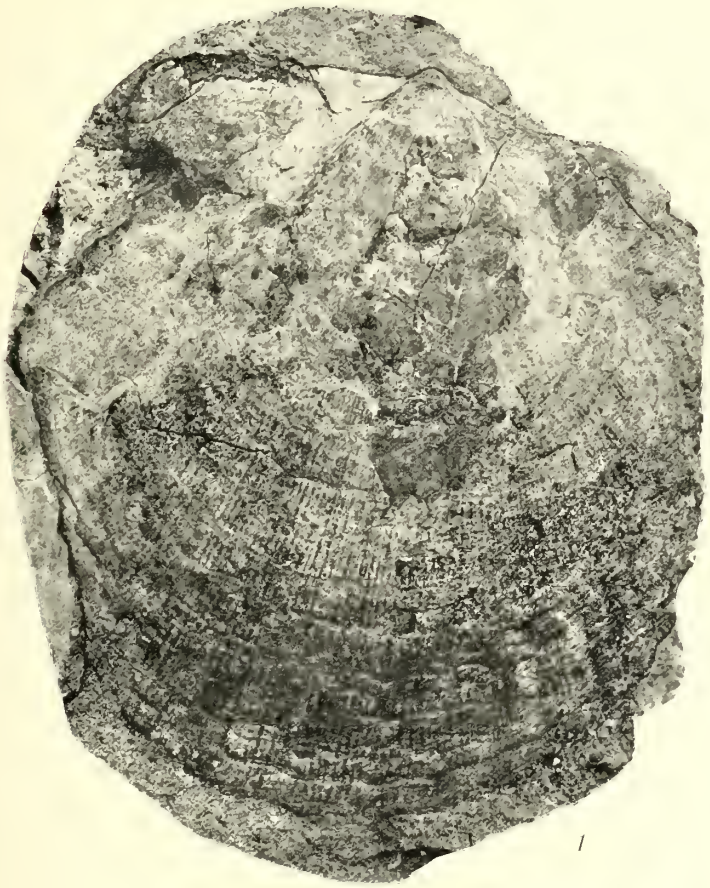
Fig. 3. Internal cast of a right valve, also slightly distorted. The resilium furrows are seen on the right half of the hinge plate, and in shadow is the impression of the chondrophore.

Aviculopecten squamuliferus, *Morris*, sp.

Fig. 4. External impression of a right valve. It will be noticed that although the costæ are of the same type as those of Plate I. Fig. 4, they are here more numerous.

Localities.

Fig. 1. Dapto.
Fig. 2. Quarry on road, near Dagworth.
Fig. 3. Maitland District.
Fig. 4. Huon Road, Tasmania.



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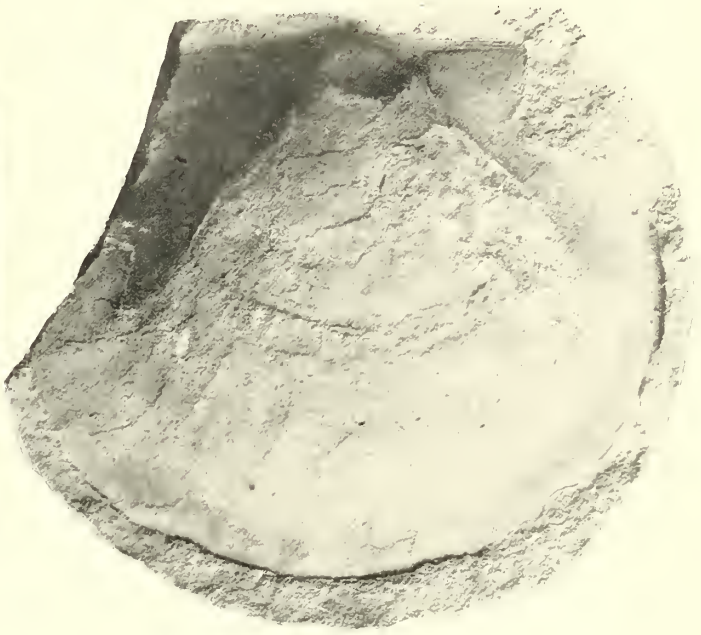

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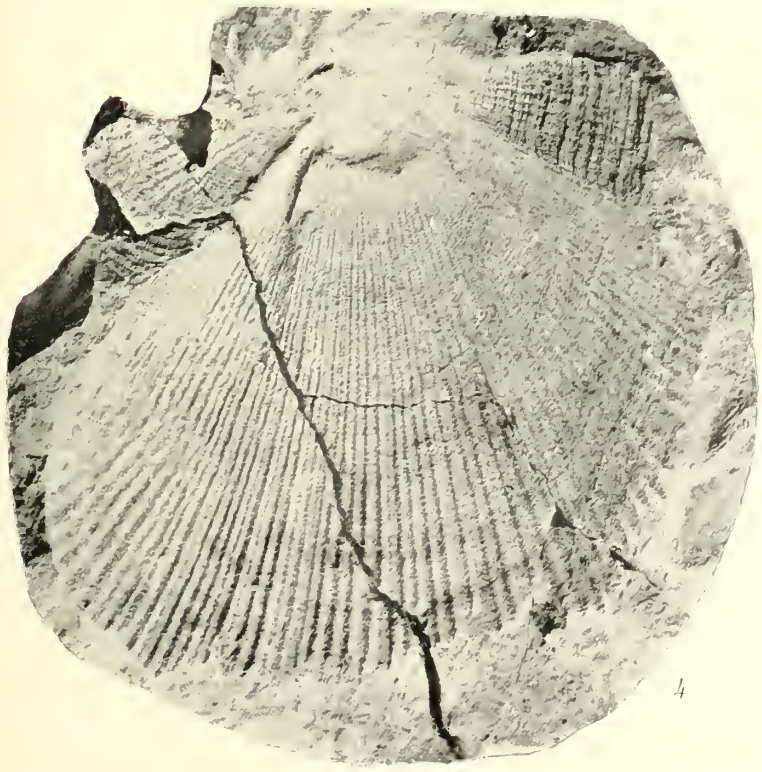

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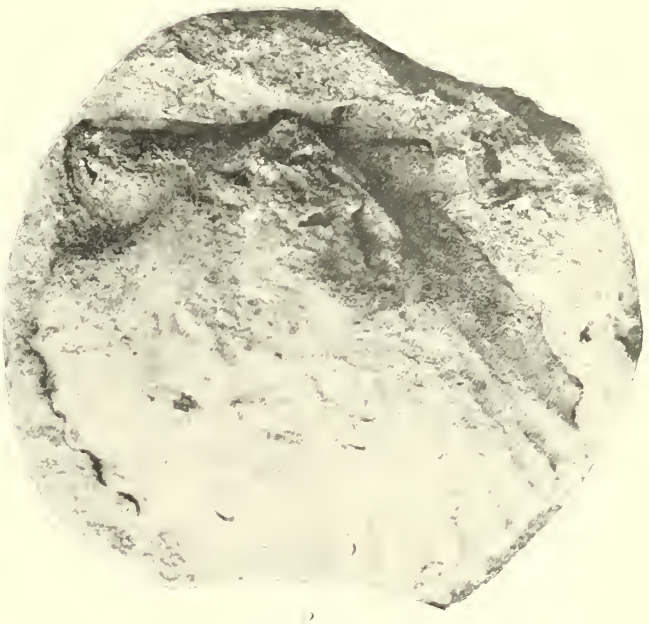

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PLATE IX.

Deltopecten subquinquelineatus, *McCoy*, sp.

Fig. 1. Internal cast of a left valve ; the primary costæ only are visible.

Fig. 2. Partially exfoliated testiferous left valve, with the primary, secondary, and tertiary costæ preserved.

Fig. 3. Internal cast of a small left valve, less the auricles ; primary and secondary costæ are discernible.

Fig. 4. Internal cast of the flat or right valve of the specimen represented in Fig. 3. Above may be seen the anterior auricle.

Fig. 5. Internal cast of portion of a right valve.

Aviculopecten Engelhardti, *Eth. fil. and Dun.*

Fig 6. Compressed internal cast of a large right valve, exhibiting obliquity, to which this species often appears to be subject. The relative proportions of the auricles are well-defined in this figure, with the byssal sinus below the anterior.

Fig. 7. Internal cast of a smaller and nearly symmetrical right valve.

Fig 8. Internal cast similar to Fig. 7, but showing anterior obliquity like that of Fig. 6.

Fig. 9. Incomplete testiferous right valve.

Fig. 10. Internal cast of a large, nearly symmetrical, left valve.

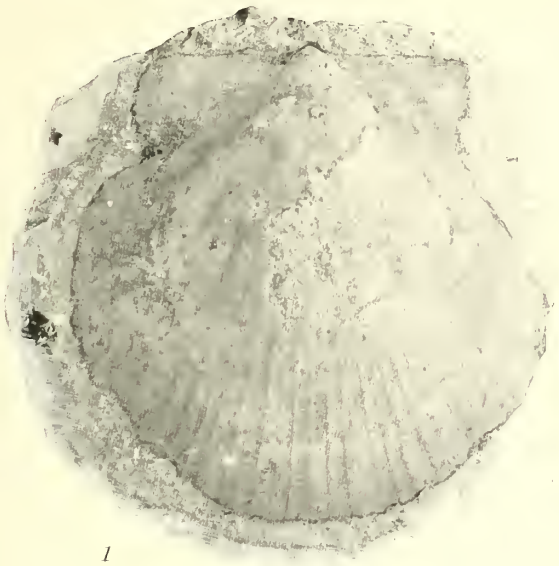
Fig. 11. Internal cast of a small left valve.

Deltopecten, sp.

Fig. 12. Internal cast of an orbicular valve, not referable to any species of *Deltopecten* herein described.

Localities.

Fig. 1. Rutherford.
Fig. 2. Dapto.
Figs. 3, 4. Mingenew, Western Australia.
Fig. 5. Farley.
Fig. 6. Shoalhaven District.
Figs. 7, 8. Cabbage Tree Point, Shoalhaven.
Fig. 9. Wollombi Road.
Fig. 10. Near West Maitland.
Fig. 11. Farley.
Fig. 12. Tokal, Paterson.



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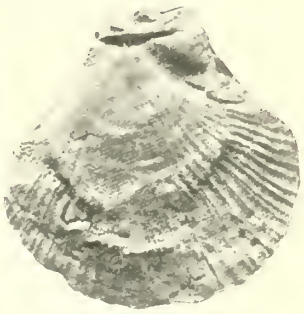

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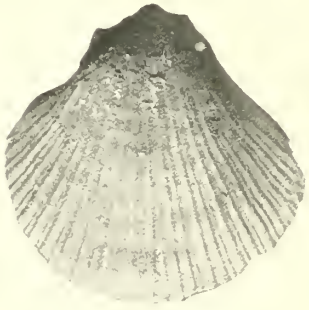

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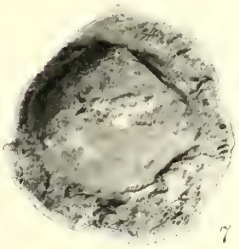

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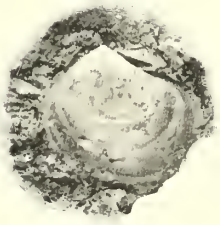

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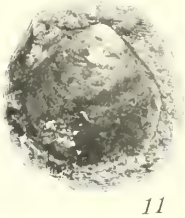

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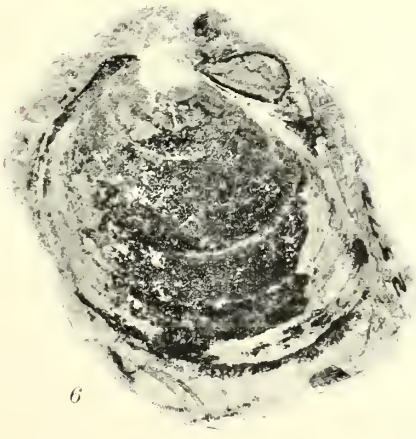

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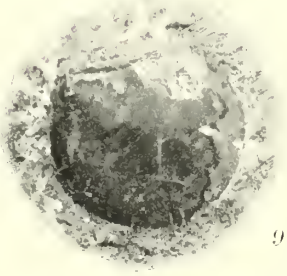

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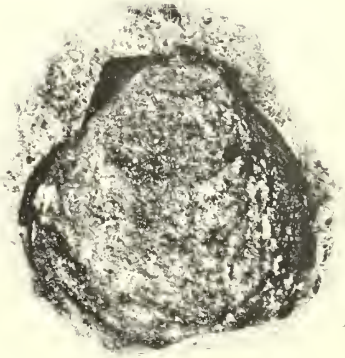

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PLATE X.

Deltopecten leniusculus, *Dana*, sp.

Fig. 1. Exfoliated left valve with defective auricles.

Fig. 2. Exfoliated right valve of same specimen (Fig. 1). Faint traces of the linear costæ are perceptible on the edges of some of the concentric laminæ.

Deltopecten limæformis, *Morris*, sp.

Fig. 3. Internal cast of the united valves, the umbo of the convex valve protruding above, and the cast of the large chondrophore seen in the centre of the cardinal margin.

Fig. 4. Decorticated example of a convex valve, devoid of auricles.

Aviculopecten Mitchelli, *Eth. fil. and Dun.*

Fig. 5. Testiferous right valve, with the costo-radiate anterior auricle.

Deltopecten Fittoni, *Morris*, sp.

Fig. 6. More or less exfoliated left valve. The linear costæ are visible in places on the major costæ.

Localities.

Figs. 1, 2. Maitland District.
Fig. 3. Nowra
Fig. 4. Ravensfield
Fig. 5. Pokolbin.
Fig. 6. Illawarra District.

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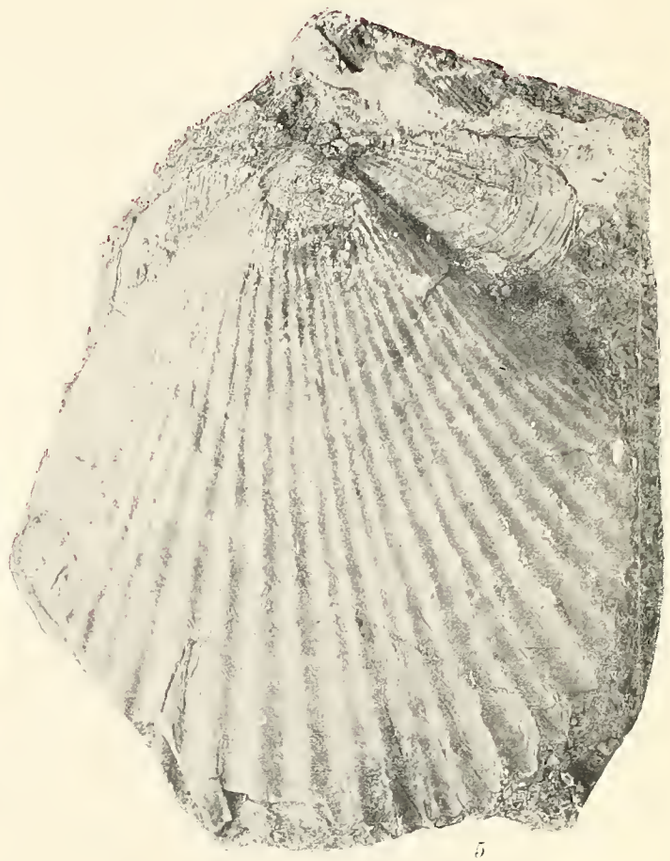

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PLATE XI.

Deltopecten limæformis, *Morris*, sp.

Fig. 1. A greatly exfoliated convex valve displaying the lateral oblique sulcus, and faint costæ.

Fig. 2. Concavo-convex valve of the same specimen (Fig. 1) in a similar condition of preservation, and the costæ again faintly perceptible.

Deltopecten leniusculus, *Dana*, sp.

Fig. 3. External impression of the flat or right valve, with both auricles preserved, as well as the costæ and latilaminæ.

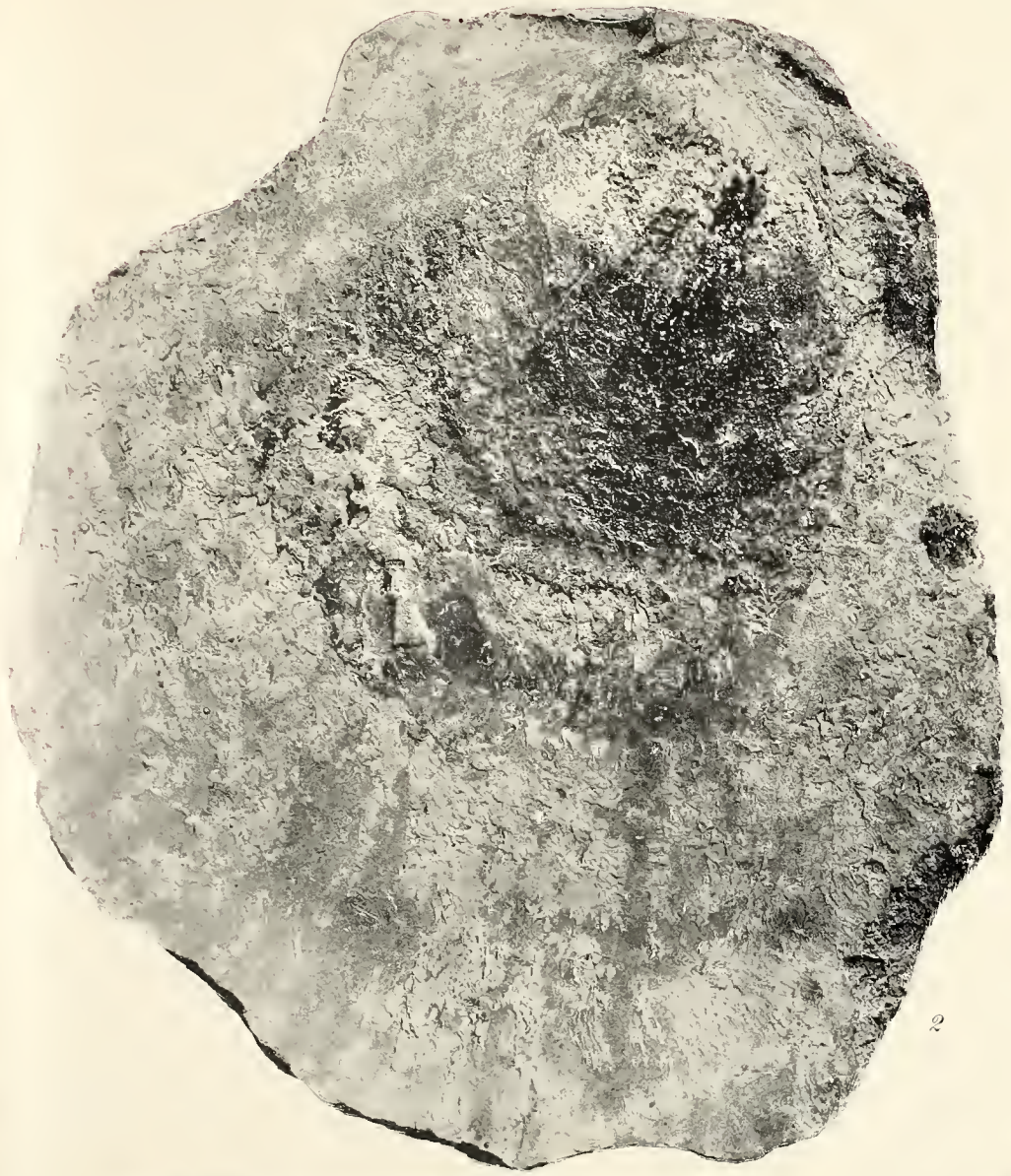
Aviculopecten profundus, *De Koninck* (?).

Fig. 4. Internal cast of a right valve, believed to be that of this species.

Fig. 5. Natural relief from an external impression of a similar right valve ; the costæ are shown crossed by close frills.

Localities.

Figs. 1, 2. Maria Island, Tasmania.
Fig. 3. Near Dee's Hotel, West Maitland.
Fig. 4. Ravensfield.
Fig. 5. Rutherford.



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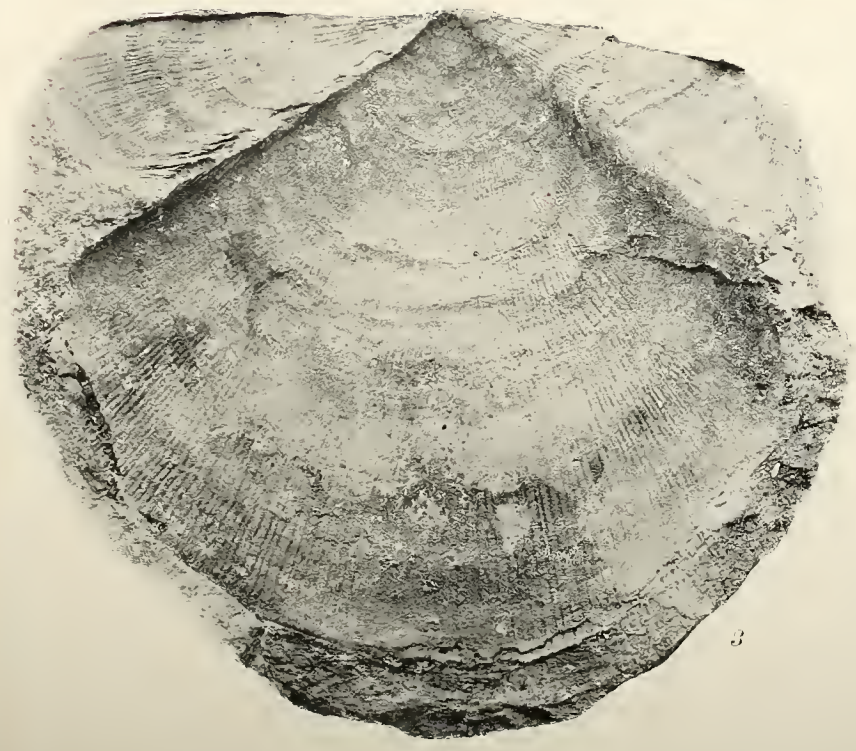

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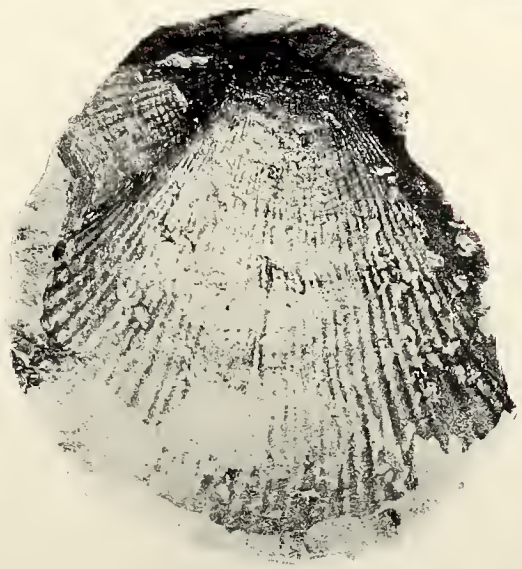

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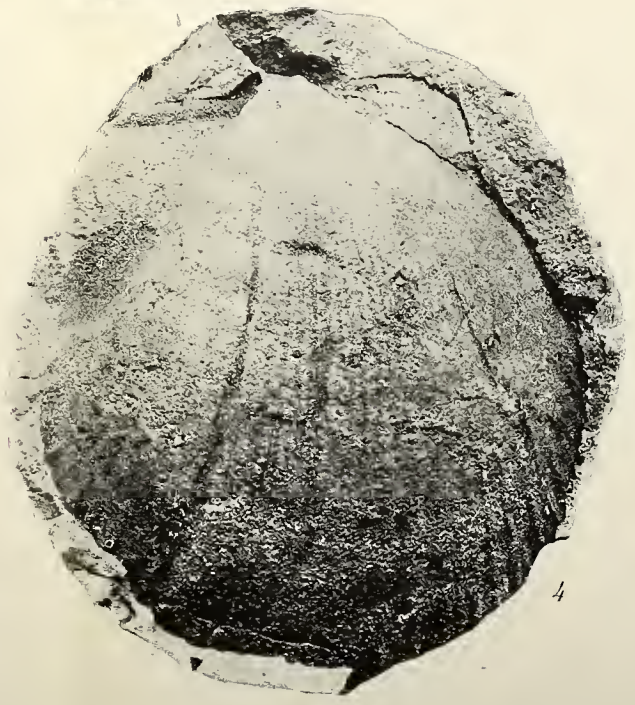

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PLATE XII.

Aviculopecten, sp.

Fig. 1. Right valve of an *Aviculopecten* allied to *A. Sprenti*, on the surface of a weathered slab of polyzoal shale.

Deltopecten subquinquelineatus, *McCoy*, sp.

Fig. 2. Testiferous left valve, with the primary, secondary, and tertiary costæ distinctly visible.

Fig. 3. Exfoliated right valve of the same specimen (See Pl. XIV, Fig. 1.)

Aviculopecten ponderosus, *Eth. fil. and Dun.*

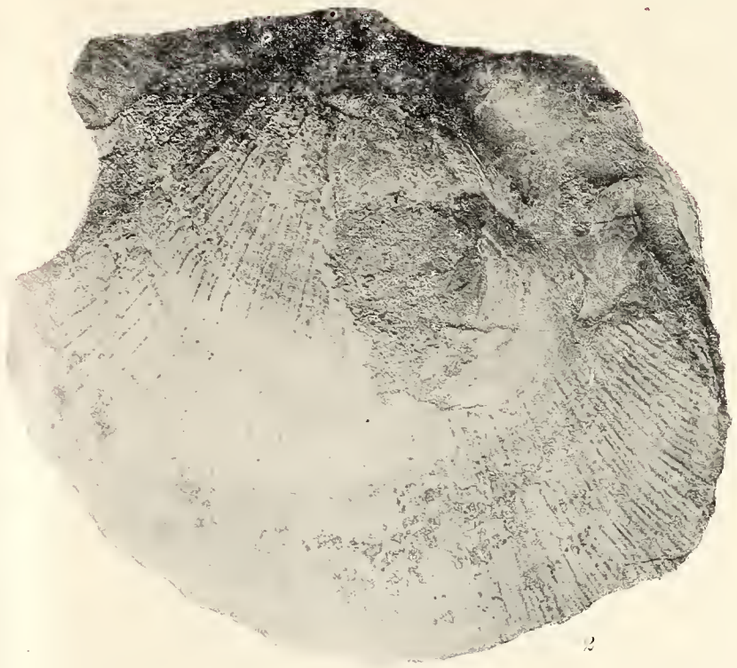
Fig. 4. Convex valve of a partly testiferous example.

Aviculopecten Mitchelli, *Eth. fil. and Dun.*

Fig. 5. Internal cast of a right valve, with the wide byssal sinus dividing off the anterior auricle.

Localities.

Fig. 1. Near Cessnock.
Figs. 2, 3. Gerringong.
Fig. 4. Portion 97, Parish Milfield, County Durham.
Fig. 5. Reservoir, West Maitland.



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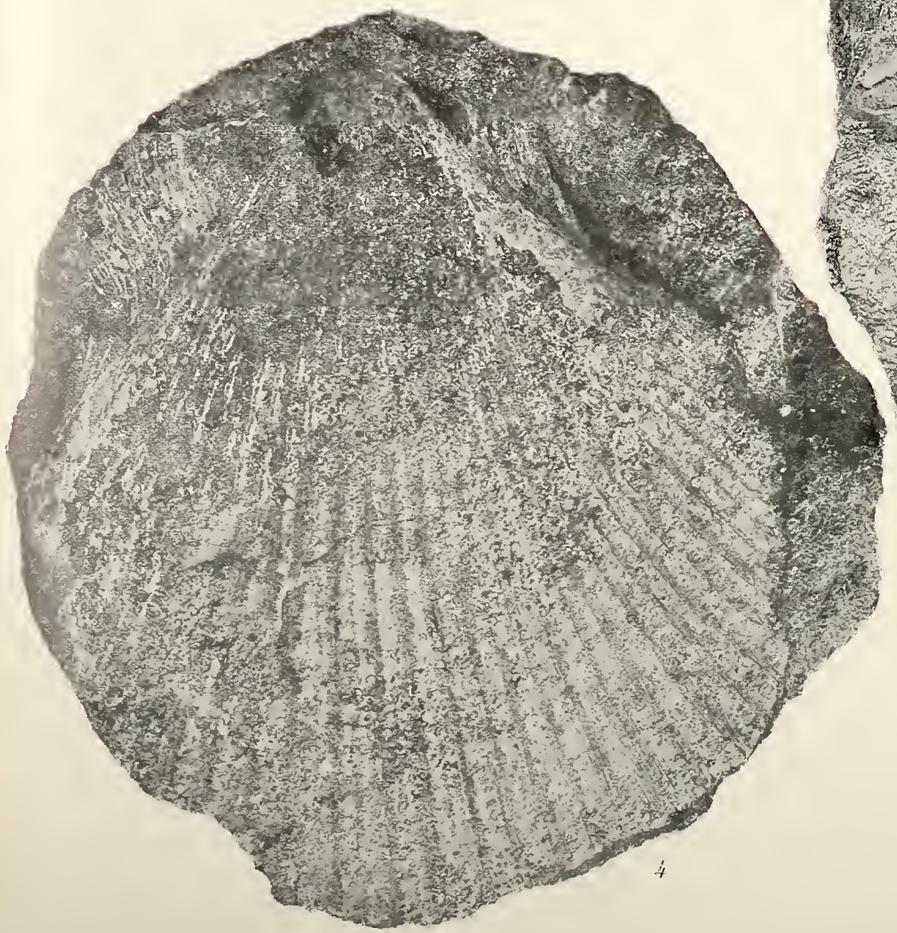

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PLATE XIII.

Aviculopecten Sprenti, *Johnston*.

Fig. 1. Large left valve, probably nearly full grown, exhibiting the outward sweep of the costæ, and traces of spines on the anterior side.

Deltopecten subquinquelineatus, *McCoy*, sp.

Fig. 2. Outline of section across a specimen, showing the relative convexity of the valves.

Aviculopecten Mitchelli, *Eth. fil. and Dun*.

Fig. 3. Outline of a perfect specimen, with the valves in apposition to show the relative convexity.

Deltopecten farleyensis, *Eth. fil. and Dun*.

Fig. 4. External impression of a right valve.

Fig. 5. A similar impression, the auricles more perfect than those of Fig. 4, the body of the valve less so.

Fig. 6. Internal cast of a left valve, with the chondrophore.

Deltopecten obliquatus, *Eth. fil. and Dun*.

Fig. 7. Internal cast of a left valve.

Deltopecten subquinquelineatus, *McCoy*, sp.

Fig. 8. External impression from a relief of a left valve on which the three orders of costæ are shown.

Aviculopecten Sprenti, *Johnston* (?).

Fig. 9. Internal cast of a left valve.

Aviculopecten tenuicollis, *Dana*, sp.

Fig. 10. Left valve, partly testiferous; the delicate concentric lines are shown on the umbonal region.

Fig. 11. Internal cast of a left valve.

Fig. 12. Internal cast of a larger left valve.

Localities.

Fig. 1. Pokolbin
Fig. 2. Wollongong.
Fig. 3. Allandale.
Fig. 4. Farley.
Fig. 5. New Golden Age Mine, Boorook.
Fig. 6. Ravensfield
Fig. 7. Porter's Bay, Tasmania.
Fig. 8. Maitland District (Paterson ?).
Fig. 9. Farley.
Figs. 10–12. Ravensfield.

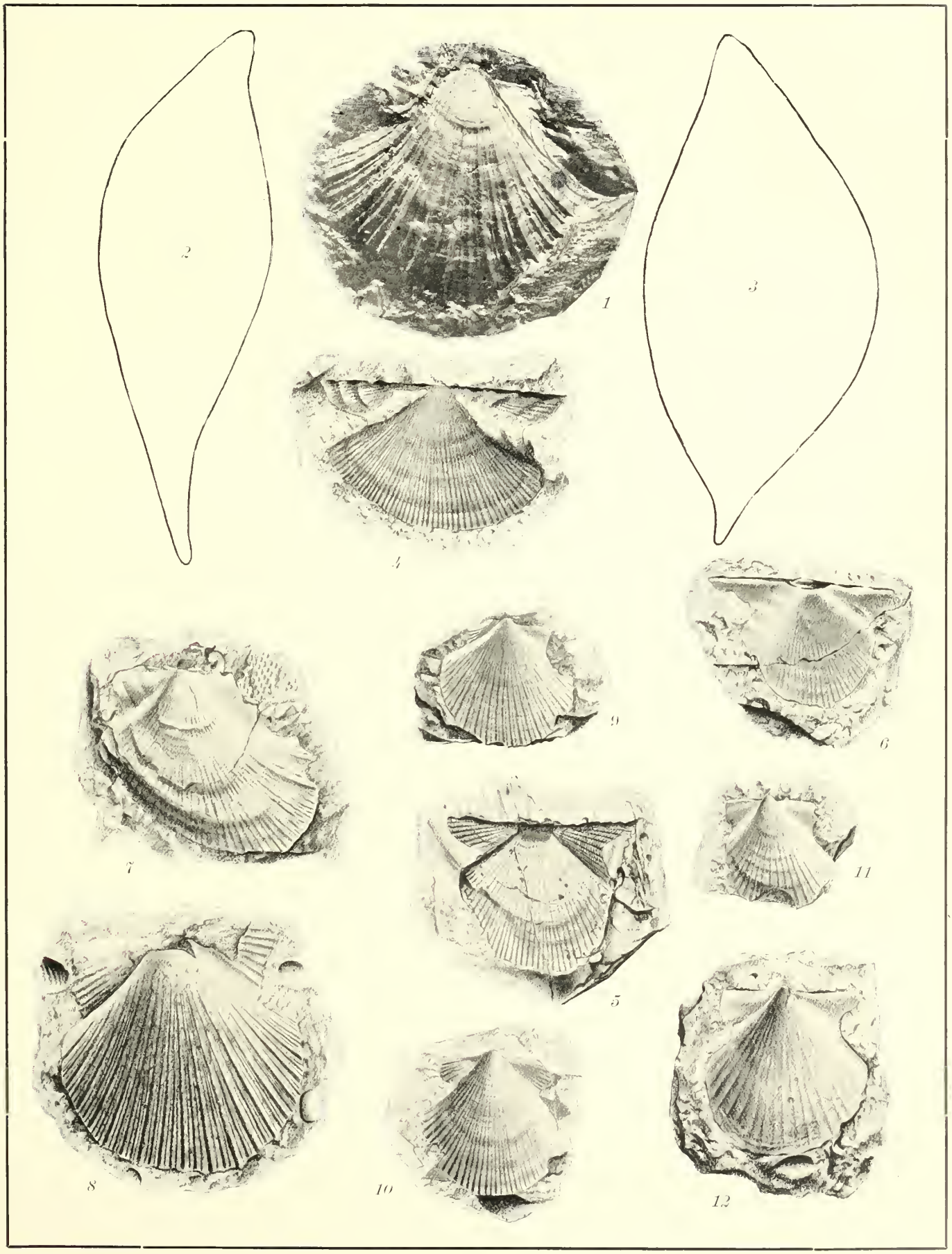
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PLATE XIV.

Deltopecten subquinquelineatus, *McCoy*, sp.

Fig. 1. United valves of the cardinal margins, showing the wide gap for the reception of the resilium, and the central chondrophore (See Pl. XII, Figs. 2, 3).

Deltopecten wingenensis, *Eth. fil. and Dun.*

Fig. 2. Cast of a left valve, showing primary and secondary costæ.

Fig. 3. A similar but smaller valve. (This drawing has been canted too much to the right.)

Fig. 4. Cast of the flat right valve.

Aviculopecten tenuicollis, *Dana*, sp.

Fig. 5. Internal cast of a left valve, with primary and secondary costæ.

Aviculopecten Engelhardti, *Eth. fil. and Dun.*

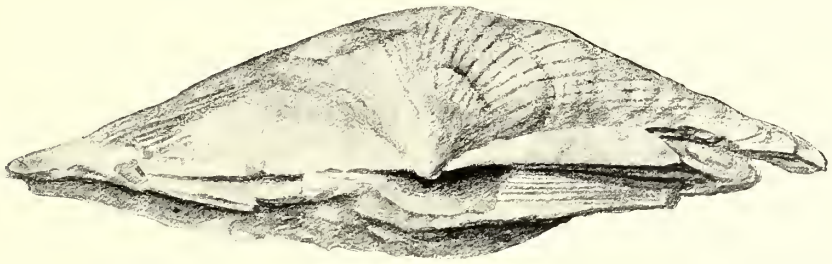
Fig. 6. Internal cast of an uncompressed right valve, displaying traces of radiating costæ.

Fig. 7. Internal cast of the left valve of the same specimen.

Fig. 8. The united valves (Figs. 6 and 7) seen from above, showing almost equal convexity.

Localities.

Fig. 1. Gerringong.
Fig. 2. Portion 110, Parish Wingen, County Brisbane.
Fig. 3. Portion 110, Parish Wingen, County Brisbane.
Fig. 4. Portion 110, Parish Wingen, County Brisbane.
Fig. 5. Ravensfield.
Figs. 6–8. M.P. 5, Parish Heddon.



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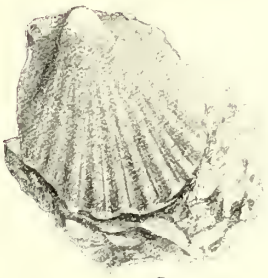

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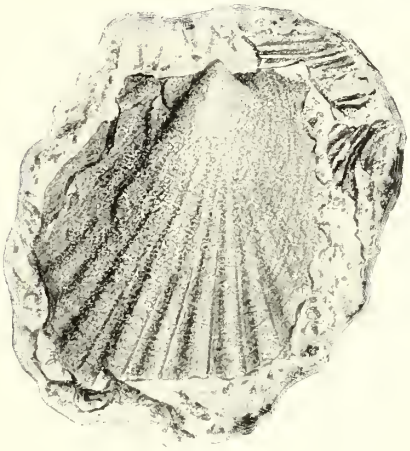

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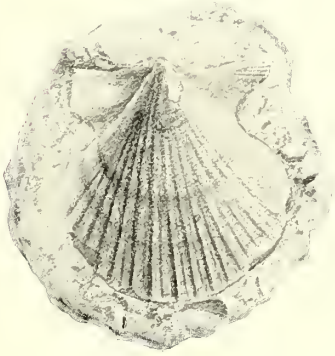

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PLATE XV.

Entolium aviculatum, *Swallow*, sp. (?)

Fig. 1. More or less decorticated valve, with slightly elevated auricles.

Fig. 2. Interior of a valve, with elevated auricles, one hidden by matrix.

Fig. 3. Entirely decorticated specimen (not an internal cast) with normal auricles, impressions of the umbonal diverging ridges and linear concentric sculpture.

Fig. 4. Entirely decorticated example (not an internal cast), with normal auricles showing lateral obliquity, which sometimes occurs in species of this genus.—x 2.

Aviculopecten ptychotis, *McCoy*, sp.

Fig. 5. Internal cast of a right valve, with a long anterior auricle separated by a deep byssal sinus. —x 2.

Fig. 6. Internal casts of right and left valves, contiguous to one another, although not in apposition. The anterior auricle of the right valve displays two radiating costæ.

Fig. 7. Internal cast of a right valve, with a similar anterior auricle to that of the like value in Fig. 6.

Aviculopecten tessellatus, *Phillips*, sp.

Fig. 8. Internal cast of portion of a left valve. —x 2.

Fig. 9. Nearly entire internal cast of a left valve, exhibiting the pointed dorso-lateral angle, and prolongation of the posterior costæ into free spines.—x 2.

Aviculopecten, sp.

Fig. 10. Testiferous valve, believed to be identical with that referred by De Koninck to *A. granosus*, J. de C. Sby., sp.

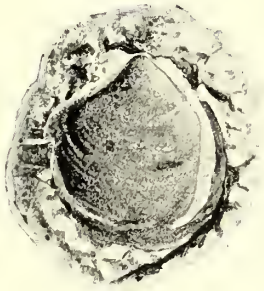
Aviculopecten, sp.

Fig. 11. Decorticated left (*l*) valve, with plain costæ.

Fig. 12. Less decorticated left (?) valve, believed to be identical with that referred by De Koninck to *A. knockonnicusis*, McCoy, sp. The costæ are linear and decussated by fine concentric sculpture.—x 2.

Localities.

Fig. 1. Somerton.
Fig. 2. Somerton.
Fig. 3. Somerton.
Fig. 4. West of Mount Uriari, Somerton.
Fig. 5. Near Crow's Nest, Mount Victoria, Queensland.
Fig. 6. Near Gresford.
Fig. 7. Near Gresford.
Fig. 8. Torryburn.
Fig. 9 Torryburn.
Fig. 10. West of Mount Uriari, Somerton.
Fig. 11. West of Mount Uriari, Somerton.
Fig. 12. West of Mount Uriari, Somerton.



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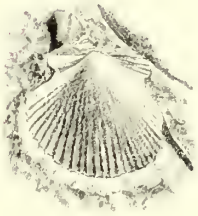

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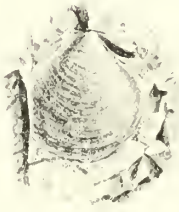

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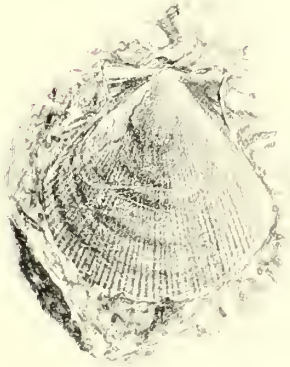

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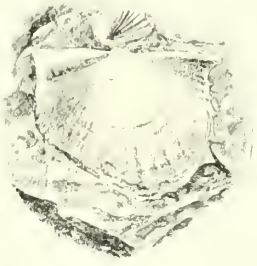

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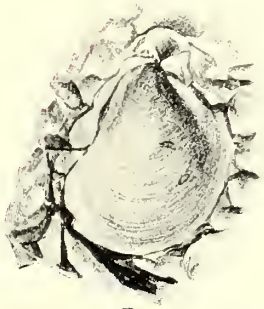

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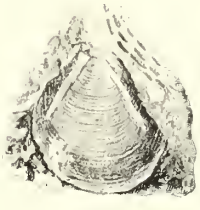

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PLATE XVI.

Deltopecten Fittoni, *Morris*, sp.

Fig. 1. Internal cast of left valve.

Aviculopecten Mitchelli, *Eth. fil. and Dun.*

Fig. 2. Portion of right valve, showing large anterior costate auricle.

Fig. 3. More convex valve, showing auricles in part.

Deltopecten farleyensis, *Eth. fil. and Dun.*

Fig. 4. Impression of right valve.

Aviculopecten Sprenti, *Johnston.*

Fig. 5. Drawing from a gelatine cast, an impression showing the form of the auricles.

Fig. 6. Imperfect specimen, showing the nature of costation in larger specimen.

Localities.

Fig. 1. West Maitland.

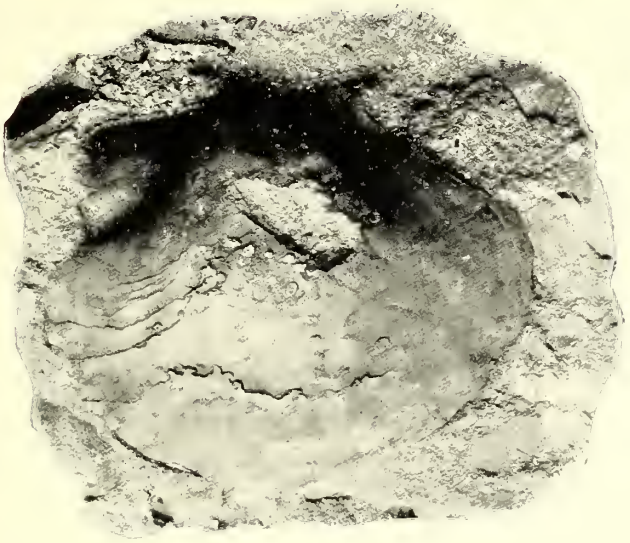
Fig. 2. Pokolbin.

Fig. 3. Pokolbin.

ig. 4. Pokolbin.

Fig. 5. One Tree Point, Tasmania.

Fig. 6. One Tree Point, Tasmania.



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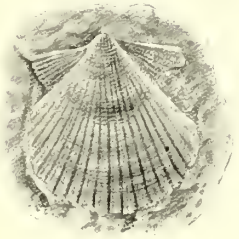

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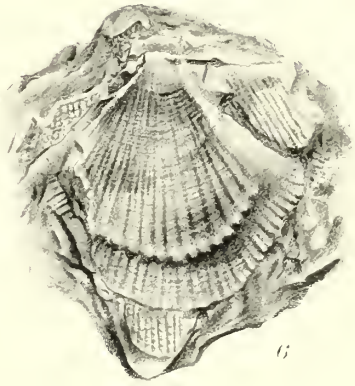

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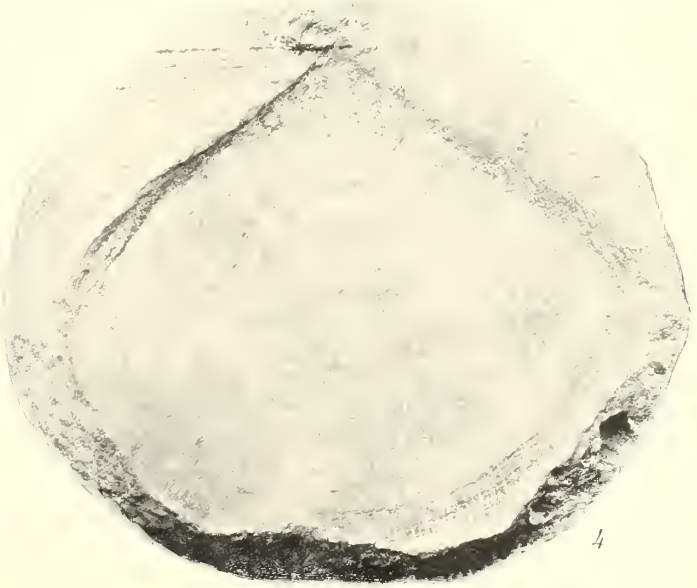

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DEPARTMENT OF MINES.

MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

E. F. PITTMAN, A.R.S.M., UNDER SECRETARY AND GOVERNMENT GEOLOGIST.

Mar. 2, 1911
12,220.

PALÆONTOLOGY, No. 5.

A MONOGRAPH

OF THE

CARBONIFEROUS AND PERMO-CARBONIFEROUS INVERTEBRATA

OF

NEW SOUTH WALES.

VOL. II.—PELECYPODA. PART II.—EURYDESMA.

BY

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Curator of the Australian Museum.

AND

W. S. DUN,

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Letter of Transmittal.

Department of Mines,
Sydney, 18th October, 1909.

Sir,

I have the honour to submit for publication Part II of Volume II of the Monograph (No. 5 of the Palæontological Series) on the "*Carboniferous and Permo-Carboniferous Invertebrata*," by Mr. Robert Etheridge, J.P., Curator of the Australian Museum, and Mr. W. S. Dun, Palæontologist to the Geological Survey Branch of this Department.

This Part of Volume II deals with *Eurydesma*, a genus which, so far as we know, is, with one exception, confined to the Lower Marine Series. It is interesting to note that certain points of resemblance indicate alliance between *Eurydesma* and *Maccoyella* (the characteristic genus of the Cretaceous Period) as well as *Meleagrina*—the recent Pearl Oyster.

I have the honour to be,
Sir,
Your obedient servant,
EDWARD F. PITTMAN,
Government Geologist.

The Honourable W. H. Wood, Esq., M.P.,
Minister for Mines.

Authors' Preface.

The Second Part of the Monograph on the Permo-Carboniferous Pelecypoda of New South Wales is devoted to an inquiry into the nature and relationship of *Eurydesma*, one of the most interesting Molluscan types of the Australian Permo-Carboniferous fauna.

Its somewhat restricted geographical distribution—Tasmania, New South Wales, and Queensland, and the Salt Range of India,—its abundance in the lower stratigraphical elements of the Permo-Carboniferous, and the peculiarities of the valve structures, have led to some attention being directed to the genus.

Though diverging greatly in outward form, analogies may be traced between *Eurydesma*, the Cretaceous *Maccoyella*, and the recent *Meleagrina*.

The umbonal region of the valves in *Eurydesma* is of extraordinary thickness, and it is interesting to note, as Mr. Charles Hedley has pointed out, that all recent bivalves comparable in valve thickness occur in tropical waters.

The specimens in the collections of the Mining and Geological Museum, the Australian Museum, the Technological Museum, and the University of Sydney have been made use of, and we have to express our indebtedness to the authorities of the various institutions for cordial assistance.

The Plates have been drawn by Mr. A. R. McCulloch, of the Australian Museum.

II.—HISTORY OF THE GENUS EURYDESMA.

1838.—To Sir Thomas L. Mitchell, Surveyor-General of New South Wales, we owe our introduction to this remarkable genus. Mitchell's first journey of exploration in Eastern Australia was made in 1831–2, "in search of the River Kundur." On arrival at a hill, now known as Harper's Hill, near Allandale, nine miles from Maitland, in the Hunter River Valley, "a volcanic grit of greenish-grey colour" was found, containing fossil shells.[1] These fossils were later examined by Mr. J. de Carle Sowerby. Amongst them a shell "near to *Isocardia*, but Mr. S. would not venture to say that it was of that genus."[2] This constitutes the first record of *Eurydesma*.

1845.—The fossils collected by Count Paul E.de Strzelecki, C.B., during his explorations in South-east New South Wales and Tasmania were described by Professor John Morris. Strzelecki visited and collected at Harper's Hill, although his published list contains no reference to *Eurydesma*,[3] but he records it from Illawarra ; in fact, as subsequent observers have not collected the genus from the southern coal-fields, it is just possible there was some mixing of specimens from the two localities. The peculiarities of Sowerby's "Isocardia" at once struck Morris, who proposed the genus *Eurydesma* for its reception,[4] remarking that it "ought to be arranged very near to *Avicula*."

1847.—During the years 1838–42 the exploration of the Pacific by the United States Exploring Expedition under Commodore Wilkes was carried out. Professor J. D. Dana accompanied the expedition as geologist. New South Wales was visited, and extensive collections were made from the Permo-Carboniferous of Harper's Hill and the Northern Illawarra District—Wollongong and Gerringong (Black Head). Two species of *Eurydesma* were obtained at Harper's Hill—*E. elliptica*, Dana, and *E. globosa*, Dana.[5]

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[1] Mitchell—Three Exped. Int. E. Austr., 1838, I, p. 14.

[2] Mitchell—*Op. cit.*, p. 15, Pl. II, figs. 1, 2.

[3] Strzelecki—Phys. Descr. N. S. Wales, &c., 1845, p. 89.

[4] Morris in Strzelecki—*Op. cit.*, p. 275.

[5] Dana—Am. Journ. Sci., 1847, IV (2), p. 158.

1847.—In November, 1847, appeared the concluding part of Sir Frederick McCoy's paper on "The Fossil Botany and Zoology of the Rocks associated with the Coal of Australia." He recorded *Eurydesma cordata*, Morris, from Arthur's Hill, N. S. Wales, without comment.[1]

1849.—The fully illustrated work embodying the geological results of the Wilkes American Exploring Expedition, by Dana, appeared about this time. In this amplification of the papers already published in the "American Journal of Science" Dana corrected Morris' description of *Eurydesma*,[2] pointing out that it was rather inequivalved than equivalve, and giving other interesting morphological details, which will be referred to later. The two species, *E. globosa* and *E. elliptica*, already described by him are retained, *Pachydomus sacculus*, McCoy, as in the second paper of the above-mentioned series, is referred to *Eurydesma*, and *E. cordata*, Morris, is discussed. In speaking of the genus, Dana says "there are some analogies to the shell of *Hippopus* and also to that of a *Meleagrina*."

Eurydesma elliptica from Harper's Hill, is a moderately thick, evenly convex, elliptical shell, with faint concentric lines of growth. *E. globosa* is a small shell, and is described as being very thick, ventricose and orbicular—it is said to have come from the "District of Illawarra," but we believe this to be a mistake. *E. sacculus*, McCoy, sp., was described by McCoy as a *Pachydomus*.[3] According to Dana, it "is much thicker than the *globosa*, as the *globosa* is thicker than the *elliptica*. It is also distinguished by its flattened lateral surface and slightly excavate lower margin"; in other words, there is evidence of a cincture more apparent in the figure than the description would lead one to believe. In McCoy's figure this is hardly, if at all, perceptible, and there appears to be considerable doubt as to whether *E. sacculus*, Dana, and *P. sacculus*, McCoy, *are* one and the same. Dana gives Harper's Hill as the locality of his species and *P. globosus*, McCoy records from Black Head or Wollongong, localities in the Illawarra District, the former from the Lower Marine Series, the latter from the Upper—the two series have hardly any species in common. *Eurydesma cordata*, Morris, Dana says, is a "much thinner species" than *E. sacculus*, and "from either of the preceding it is distinguished by its radiations and slightly flattened

[1] McCoy—Ann. Mag. Nat. Hist., 1847, XX, p. 299.
[2] Dana in Wilkes—U.S. Explor. Exped., X (Geol.), 1849, pp. 699-701.
[3] McCoy—Ann. Mag. Nat. Hist., 1847, XX, p. 301, Pl. XIV, fig. 5.

lateral surface, as well as form." Dana's figure (his Pl. VIII, figs. 1, 1*a* and our Pl. XXIII, figs. 3 and 4) does not appear to us to be a representation of a typical specimen of *E. cordata*.

1871.—Dr. F. Stoliczka gave a full generic description of *Eurydesma*, but differed from Morris in regard to its affinities. He considered that "the general form, the excavated and gaping lunula, the strong development of the ligament below the beak, and the presence of a strong cardinal tooth in the right valve all tend towards a relation of the genus to *Tridacna* and *Hippopus*"[1]. An affinity to the latter had already been suggested by Dana.

1884.—Mr. G. W. Tryon, Junr., in his "Structural and Systematic Conchology," reproduced Stoliczka's description and adopted the placing of *Eurydesma* in the Tridacnidæ.

1887.—Dr. Paul Fischer placed *Eurydesma* near *Tridacna*, assigning to it a Devonian age in error.[2]

1888.—*Eurydesma* also occurs in Tasmania, but was not included in Strzelecki's collections. Mr. R. M. Johnston records *E. sacculus*, McCoy, sp., from the Tasmanian Upper Marine Series of the Permo-Carboniferous,[3] and figures several fossils as *E. cordata*, Morris, from the Lower Marine of Maria Island, and Bridgewater[4]. The occurrence of *Eurydesma* in the Upper Marine Series is of interest, and will be referred to later on.

Of the other shells figured by Johnston more will be said subsequently —his *Notomya Beddomei* appears to be *Eurydesma hobartensis* (Syst. Acc., Pl. XVI, fig. 2), and to the same species may be referred *E. cordata*, Johnst., *non* Morris (*Ibid.*, Pl. XVII, figs. 2, 3). *Notomya Gouldi*, Johnst. (*Ibid.*, Pl. XVII, fig. 1) is our *Eurydesma cordatum*, var. *sacculum*; and his *Pachydomus globosus*, *non* Sby. (*Ibid.*, Pl. XVIII, figs. 1, 1a), and *P. Koninckl* (?) cannot, from the figures, be distinguished from *E. cordatum*.

1891.—Dr. William Waagen detected the presence of *Eurydesma* in the Permo-Carboniferous of the Salt Range, India, and drew attention to points in the structure, which will be referred to later. He supported Morris'

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[1] Stoliczka—Cret. Fauna S. India (Pal. Indica), III, Pelecypoda, Pt. 5, 1871, p. 226.
[2] Fischer—Man. Conchyl., 1887, fasc. 11, p. 1185.
[3] Johnston—Syst. Acc. Geol. Tas., 1888, p. 114.
[4] Johnston—*Op. cit.*, pp. 114, 119, Pl. XVII, figs. 2–3b, Pl. XVIII, fig. 1b, and Pl. XIX, figs. 1, 1a.

suggested reference to the Aviculidæ rather than Stoliczka's to the Tridacindæ. Three species were recorded, all Australian—*E. globosum*, Dana, *E. ellipticum*, Dana, *E. cordatum*, Morris.[1]

The principal structural features noticed by Waagen in these Indian forms were :—

(*a*) The inequality of the valves, already detected by Dana, the right being the larger.

(*b*) The absence of the gaping lunette suggested by Stoliczka.

(*c*) The existence of "a little wing projecting from the left valve and fitting into a rounded emargination of the right valve."

(*d*) A narrow byssal sinus extending "from the apex of the right valve down to the cardinal margin just in front of the emargination . . . . . and in front of the large tooth that exists in this valve."

(*e*) Byssal sinus confined to the right valve (Morris' description gave the impression that such a sinus existed in both valves).

(*f*) Morris' reference to the Aviculidæ, rather than that of Stoliczka to the Tridacnidæ, is probably the more correct.

(*g*) Disposition of the muscular impressions like that of *Meleagrina*.

(*h*) The affinities to the Aviculidæ consist of (*c*), (*d*), and (*g*).

1891.—Dr. F. Frech, in a Monograph on the Devonian Aviculidæ of Germany, included remarks on various extra-European genera. Amongst these was *Eurydesma*, described under the name of *Leiomyalina*,[2] as a subgenus of *Myalina*, De Kon. The former is said to differ from the latter in the possession of a broad, smooth, flat surface in both valves below the cartilage areas, and under the left umbo "a tooth-like swelling" (zahnartiger wulst). The shells are large, thick-tested, and occupy a position between *Myalina* and *Perna*, the form reminding Dr. Frech of that of *Aphanaia*, De Kon. The specimen is in the Royal Museum of Natural History, Berlin, and is said to have come from Kilama,[3] New South Wales. Dr. Frech remarks that other species of *Leiomyalina* were described by Dana as *Eurydesma*, from Harper's Hill—*E. ellipticum*, Dana, is a *Cardiomorpha*, but

[1] Waagen—Salt Range Fossils (Pal. Indica), IV, Pt. 2, 1891, pp. 137-43.

[2] Frech—Die Devonischen Aviculiden Deutschlands. *Abhandl. Geol. Specialkarte Preuss. Thüring. Staaten*, 1891, IX, Heft 3, p. 201.

[3] Possibly Kiama, Illawarra District—Marine beds near Kiama belong to the Upper Marine Series.

E. globosum, Dana, *E. sacculus*, Dana, and *E. cordatum*, Dana, are "typical Heteromyarians"—presumably these are the *Eurydesma* referable to *Leiomyalina*.

1892.—*Eurydesma* was recorded from the Permo-Carboniferous of the Yatton Gold-field, Queensland[1]—*E. cordata* was recognised, and possibly *E. sacculus* also.

1901.—F. Noetling, in an article on the Stratigraphical Geology of the Salt Range, places the zone of *Eurydesma globosum*, Dana, as interpreted by Waagen, in the Middle Rothliegende (Upper Permian).[2]

1902.—Dr. J. Tschernyschew mentioned the occurrence of *E. globosum* in the Middle Carboniferous of the Ural.[3]

1902.—The description and illustrations of the Berlin specimen of *Leiomyalina*, Frech, were supplemented by figures of other examples preserved in the Hamburg Museum[4] from the Dyas (Permian) of Tasmania. In addition to the characters given in the previous paper, and which serve to separate *Leiomyalina* from *Myalina*, De Kon., others are added—a single very strong cardinal tooth in each valve, and a "suspicion" of a posterior lateral tooth. Frech next accepts *E. cordatum*, Morris, as the type of *Eurydesma*, and whilst recognising Morris' figures of the latter as the best hitherto published, remarks that they exhibit neither the smooth surface, nor a suggestion of the posterior lateral tooth, modifying this statement by "it is not at all improbable that the absence of these important distinctive features is owing to the defective preservation of the original specimens." In view of this, it is hard to see how *Leiomyalina* differs from *Eurydesma*.

Frech also gives his views as to the relationship of certain characteristic Australian Permo-Carboniferous shells to *Leiomyalina*, and these are referred to, though it is not proposed to enter into further criticism at present:—

(1) *Aphanaia*, De Koninck,[5] is said to be closely related to *Leiomyalina*, and is also an abundant genus.

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[1] Etheridge—Geol. Pal. Q'land, 1892, p. 277.
[2] Noetling—N. Jahrb. Min., Beil.-Bd., XIV, 1901, p. 431.
[3] Tschernyschew—Mém. Com. Géol. Russie, 1902, XVI, No. 2, p. 727.
[4] Frech in Roemer—Leth. Pal., 1902, II, Lief. 4, p. 600, fig. *a*.
[5] De Koninck—Foss. Pal. Nouv. Galles du Sud, 1877, Pt. 3, p. 164.

(2) As related to *Leiomyalina* are also quoted *Sanguinolites Etheridgei*, De Kon.,[1] *Sanguinolites curvatus*, De Kon.,[1a] *Mytilus Bigsbyi*, De Kon.,[2] and *Mytilus crassiventer*, De Kon.[3]—which appear to us beyond all doubt to represent genera widely separated from *Leiomyalina* (*Eurydesma*).

Finally, he states that *L. antarctica* is, *perhaps*, identical with *Eurydesma globosum*, Dana.[4]

1903.—Frech's last description of *Leiomyalina* had hardly appeared when Professor G. Boehm, who had made collections of *Eurydesma* and the associated fossils, at Maria Island, Tasmania, opposed the establishment of *Leiomyalina* on the ground of its identity with *Eurydesma*.[5] He says:—"What I had assigned to the genus *Eurydesma*, Mr. Frech refers to his genus or subgenus *Leiomyalina*," and, "already (in 1902) I have stated, before Frieburg geologists, that according to my views, *Leiomyalina* may be united with *Eurydesma*." [6]

Boehm considers that the three forms which Frech, in his second article, unites under *L. antarctica*, belong perhaps to three, but certainly to two perfectly distinct species. He further criticises Frech's reference of *Eurydesma ellipticum*, Dana, to *Cardiomorpha*, and asks in what character is this species "generically distinct from the other three." [7] Having examined Frech's material, Boehm disputes the presence of a hinge-tooth in the left valve of *Leiomyalina antarctica*, characterising the statement as "particularly inaccurate"; he, however, generally endorses the interpretation of the hinge characters given by Dana and Waagen.

According to Frech, as we have already seen, the chief peculiarity of *Leiomyalina* is the extended, broad, flat surface under the cartilage area—to this, Boehm applies the term "hinge plate,"[8] and states that he was "unable to observe a decided flat surface, either in the illustration or in the specimens in the Hamburg Museum."[9] Boehm also opposes the fresh-water origin of *Eurydesma* suggested by Noetling.[10]

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[1] *Op. cit.*, p. 124, Pl. XVI, fig. 2.
[1a] *Op. cit.*, p. 126, Pl. XVII, fig. 4.
[2] *Op. cit.*, p. 150, Pl. XXI, fig. 1.
[3] *Op. cit.*, p. 150, Pl. XXI, fig. 2.
[4] Dana—Wilkes U.S. Explor. Exped., X, (Geol.), p. 700, pl. VII, f. 7.
[5] Boehm—Centralblatt Min. Geol. Pal., 1903, pp. 296-300.
[6] Boehm—*Op. cit.*, p. 297.
[7] Boehm—*Op., cit.* p. 298.
[8] Boehm—*Op. cit.*, p. 299.
[9] Frech—Leth. Pal., *loc. cit.*, p. 600, fig. a.
[10] Frech—Leth. Pal., *loc. cit.*, p. 641, f. n.

III.—FORM AND STRUCTURE OF THE GENUS EURYDESMA.*

In dealing with the general characters of the genus, it must be understood that, according to our interpretation, there occur in Australia two species of *Eurydesma*, passing through well-marked gradations and varieties—*E. cordatum*, Morris, and *E. hobartense*, Johnston. *E. globosum*, Dana, *E. sacculum*, *E. ellipticum*, Dana, and *E. antarcticum*, Frech, sp., are considered as appropriately grouped with *E. cordatum*. The Indian forms described by Waagen do not belong to our species, nor is it quite certain that they are species of *Eurydesma*, Morris.

For the purpose of convenience, it is proposed to group the descriptions of the structure under headings.

1. *Form and Contour.*—The contour entirely depends on the position in which the shell is placed. If oriented in accordance with the Aviculid affinities suggested, *i.e.*, with the posterior dorsal margin horizontal, the outline is either obliquely cordate (*E. cordatum*) or obliquely oval (*E. hobartense*).

The shell is circular, transversely oval, suborbicular, or irregularly elliptical, sometimes even becoming somewhat cordate. The suborbicular outline is seen in Dana's figure of *E. cordata*, Morris,[1] the elliptical in his *E. elliptica*,[2] and the cordate outline is more particularly approached in Sowerby's figure of *E. cordata*, Morris.[3] Dana's *E. globosa*[4] is even more cordate, while Waagen describes his *E. ellipticum* as transversely oval,[5] and *E. cordatum* as "nearly circular."[6]

Eurydesma attained a considerable size, and was a heavy shell; one individual of *E. cordatum* measures six and three-quarter inches from the umbo to the ventral margin, and five and a half inches across the valves. *E. hobartense* never attains these proportions.

*Note.—In this section we attach to the various forms of *Eurydesma* the specific names as applied by their authors; our interpretation will be found later.

[1] Dana in Wilkes—Pl. VIII, fig. 1.

[2] Dana—*Op. cit.*, Pl. VII, figs. 6 a and b.

[3] Sowerby in Mitchell—*Op. cit.*, Pl. II, fig. 1.

[4] Dana in Wilkes—*Op. cit.*, Pl. VII., fig. 7.

[5] Waagen—Salt Range Fossils, IV, Pts. 5-8, 1871, p. 141.

[6] Waagen—*Loc. cit.*, p. 142.

2. *Depth of Valves.*—The valves are invariably strongly convex, in some cases to a high degree. This reaches its utmost development in *E. cordata*, as figured by Dana,[1] and at a minimum in *E. elliptica*, Dana.[2] Morris speaks of *E. cordata* as a "very ventricose and cordiform shell."[3] The width of the valves is also clearly shown in one of Sowerby's figures, a typical internal cast of *E. cordata*, Morris.[4] From the examination of a large series of specimens we find that the ventricosity or degree of convexity of the valves in *E. cordatum* is high, and in elevation the valves are much arched. This is most marked in the sub-umbonal region, thence the convexity rapidly decreases towards the ventral margins, where the valves are more or less compressed or "thin." The large specimen (Pl. XVII), already referred to, has a girth of fourteen and a half inches. *E. hobartense*, as compared with the type species, is a compressed form, with a thickness, through the apposed valves, of four and a quarter inches.

3. *Valves.*—The valves were closely apposed in both species, there being no gape. We are in accord with Dr. Waagen in that the "gaping lunette" referred to by Stolickza does not exist.[5]

The cardinal margins are sharply arched in both species, the angle of the anterior side being decidedly the more acute. The margins of the valves were closely apposed, leaving no dorsal or anterior gape as in *Meleagrina*.

The portion which is regarded as the ventral margin is relatively of small extent, sharply and obliquely curved. This region is invariably regularly convex, or rounded, except in Dana's *E. sacculus*,[6] where the margin is insinuate immediately opposite to the umbonal region, corresponding to shallow cinctures. It must be pointed out that if Dana's species be *Pachydomus sacculus*, McCoy,[7] it differs widely from McCoy's figure, in that the latter shows only the merest ventral inflection on the valve figured. The greatest degree of convexity is seen in Dana's figure of *E. cordata*, Morris,[8] where it forms almost a semicircle; in *E. elliptica*, Dana,[9] the curvature is much wider.

[1] Dana—*Op. cit.*, Pl. VIII., fig. 1a.
[2] Dana—*Op., cit.*, Pl. VII., figs. 6 *b* and c.
[3] Morris in Strzelecki—Phys. Descr. N. S. Wales, p. 276.
[4] Sowerby in Mitchell—*Op. cit.*, Pl. II , fig. 2.
[5] Waagen—Salt Range Fossils, *loc. cit.*, p. 13.
[6] Dana in Wilkes—*Op. cit.*, Pl. VII, fig. 8*a*.
[7] McCoy—Ann. Mag. Nat. Hist., 1847, XX, Pl. XIV., fig. 5.
[8] Dana in Wilkes—*Op. cit.*, Pl. VIII, fig. 1.
[9] Dana in Wilkes—*Op. cit.*, Pl. VII, figs. 6*a*, *d*.

The anterior ends in *E. cordatum* are comparatively small, nearly the whole of the valves being posterior to a line dropped from the umbonal apices. This species is, therefore, according to our view, very inequilateral, and not, as Morris stated, "nearly equilateral."[1] This condition also obtains in *E. hobartense.*

The anterior regions may be described as antero-ventrally protuberant, the margin below the lunule fairly convex.

In both Dana's and Morris' figures the anterior ends of the valves are always represented as more produced than the posterior,[2] and more compressed[3]; the marginal outline is also more elliptical than the posterior (*E. elliptica*, Dana).

The large posterior ends are highly inflated immediately behind and below the umbonal region, giving the valves their great ventricosity. The broad convex surfaces rapidly pass into the steep posterior slopes, but these are not separated from the umbonal slopes by diagonal ridges; there is no marginal inflection, the dorso-posterior angles being rounded off. There are no traces of posterior alations, though the valves are sometimes flattened in that region. The ventral and posterior margins form a wide, somewhat oblique curve. These characters are clearly seen in *E. cordatum* and less so in *E. hobartense.*

It must be pointed out that a small posterior wing-like extension is to be seen in one of Dana's figures of his *E. elliptica*[4]; but this must be regarded as, at any rate, a very inconstant character.

4. The umbones are prosogyrate, incurved, and with acute, small apices, always approximate, in some cases touching, but usually slightly separated—in only one case have we seen them any appreciable distance apart (Pl. XVIII., fig. 3). The umbonal regions are very pronounced, high, and prominent, especially in *E. cordatum.*

Morris described the umbones of *Eurydesma cordata* as incurved, thick, and approximate[5]; Dana as approximate, incurved, and curving a little

[1] Morris in Strzelecki—Phys. Descr. N. S. Wales, &c., 1845, p. 276.
[2] Morris in Strzelecki—*Op. cit.*, Pl. XII.; Dana in Wilkes—*Op. cit.*, Pl. VII., fig. 6*c*.
[3] Dana in Wilkes—*Op. cit.*, Pl. VII., fig. 6*a*.
[4] Dana in Wilkes—*Op. cit.*, Pl. VII., fig. 6*d*.
[5] Morris in Strzelecki—*Op. cit*, p. 276.

forward.[1] Stoliczka, reviewing Morris' and Dana's works, regarded them as strongly incurved.[2] Waagen, in writing of *E. globosum*, Waagen says:—"We find that this latter [apex or umbo] is very narrowly rounded, very strongly prominent, and not very much bent over."[3] In *E. ellipticum*, Waagen, "the apex of both valves is tolerably broadly rounded"; and in *E. cordatum*, Waagen, the umbones are nearly median, "the apex is tolerably prominent, but not distinctly marked off from the remainder of the shell," but well bent over and pointed.

5. *Inequality of Valves.*—Dana described the shell of *Eurydesma* as inequivalve, figuring the valves of *E. elliptica* in support.[4] In his figure it will be seen that the umbo of the left valve is at a lower level than that of the right. From an examination of a large series, it is found that this is a very variable character. It is certainly present in some specimens of *E. cordatum* to a slight extent; it is just as certainly absent in others—on the other hand, the hinge-plate of the left valve always appears to be a more massive structure than that of the right valve, as will be seen later (p. 52), notwithstanding that the articulus of the right valve is a more complex structure than that of the left. Waagen considered the right valve to be the larger,[5] and drew particular attention to *E. ellipticum*, Waagen.[6] As a general rule the valves in our specimens are equal when viewed externally. Morris described the shell as equivalve, Dana as inequivalve. This inequality is very clearly shown in two of his figures of *E. elliptica*,[7] where the left valve not only has a smaller and lower umbo, but is also decidedly less convex.

The flanks are, as a rule, evenly rounded from apex to ventral margin, but certain specimens figured by Dana show variations. In *E. elliptica*, Dana,[8] the regular contours are directed inwards on approaching the ventral margins and then again bent slightly outwards, the profile being slightly sigmoidal—this is more apparent in the left than in the right valve. In Dana's *E. sacculus* the ventral inflections already referred to end above in ill-defined longitudinal cinctures, almost extending for half the height of the valves.

[1] Dana in Wilkes—*Op. cit.*, p. 699.
[2] Stoliczka—Cret. Fauna, *loc. cit.*, p. 226.
[3] Waagen—Salt Range Fossils, *loc. cit.*, p. 138.
[4] Dana in Wilkes—*Op. cit.*, p. 699, Pl. VII., fig. 6*c*.
[5] Waagen—Salt Range Fossils, *loc. cit.*, p. 138.
[6] Waagen—*Ibid.*, p. 141.
[7] Dana in Wilkes—*Op. cit.*, Pl. VII., figs. 6*b* and *c*.
[8] Dana in Wilkes—*Op. cit.*, Pl. VII. figs. 6*b* and *c*.

To follow Stoliczka's interpretation of *Eurydesma* it would be necessary to regard the genus as possessing a slight anterior gape,[1] but Waagen says, "there does not exist a trace of such a gape, the valves being perfectly closed in front in the manner figured by Dana in *Eurydesma globosum*, Dana."[2]

6. *Lunule.*—The anterior cordate depression below the umbones is large and deep, and in position corresponds to the lunule of other Pelecypoda. It is not circumscribed by ridges, but its whole surface is roughened by the laminar structure of the test. These laminæ are crowded together in the subumbonal region, and are no longer visible externally; but in the left valve, at least, they roughen the upper or protruding surface of the cardinal fold. A similar, but more contracted, lunule-like depression in *Meleagrina* is equally lamellate. Analogous structures also occur in other genera, as Dall remarks:—"In *Unio*, for instance, ... in most species is a depressed space, homologous with the lunule of *Venus*, over which the epidermis is raised in dense elevated lamellæ."[3]

The earlier writers also referred to this region. Stoliczka, in his brief notice of *Eurydesma*, referred it to the Tridacnidæ, partly on the supposed existence of an "excavate and gaping lunula."[4] Waagen, on the other hand, denies the presence of "a gaping lunette,"[5] although, in describing *E. globosum*, Waagen, he refers to "a distinct emargination in the strongly sloping outline which corresponds to a kind of lunula situated in front of the apex, and very deeply excavated."[6] But this is a different interpretation to that of Stoliczka.

In speaking of the same species, Waagen also says:—"Yet more forward . . . . . there extends the deeply excavated anterior lunula, characteristic of the genus, and reaching half-way down to the anterior margin of the shell."[7] In the left valve of the same species, "in front of the apex, there extends here a large, smooth, well-excavated lunula, the cardinal margin of which projects vertically strongly in a semi-elliptical curve, and

[1] Stoliczka—Cret. Fauna S. India, IV, Pts. 5-8, 1871, p. 137.
[2] Waagen—Salt Range Fossils, IV, Pt. 2, 1891, p. 137.
[3] Dall—Trans. Wagner Free Inst. Sci., 1895, III, Pt. 3, p. 501.
[4] Stoliczka—Cret. Fauna S. India, III, Pts. 5-8, 1871, p. 226.
[5] Waagen—Salt Range Fossils, IV, Pt. 2, 1891, p. 137.
[6] Waagen—*Loc. cit.*, p. 138.
[7] Waagen—*Loc. cit.*, p. 139.

reaches with its upper termination to near the apex."[1] In *E. ellipticum*, Waagen, the lunule is not "very distinctly developed," and in *E. cordatum*, Waagen, it is represented by a "shallow emargination," and "not very excavated."[2]

7. *Articulus, or Hinge Region.*—This essential part of the shell may be considered under four sub-heads:—(*a*) hinge-plate, (*b*) the resilifer, (*c*) byssal sinus, (*d*) the cardinal folds (the so-called teeth), and the inflections representing the sockets.

We are led to regard the whole of these structures as integral portions of the respective "hinge-plates," and fail to appreciate the importance assigned by Dr. Frech to an upper and lower plate as distinctive of his genus *Leiomyalina* (see p. 44). In this connection Professor Boehm says:—"I, at least, was unable to observe a decided flat surface either in the figures or in the originals at Hamburg."[3] Furthermore, we do not admit the presence of "teeth," in the strict sense of the word, in the articulus of *Eurydesma*, and a ligament is absent. Our conception of the hinge region of *Eurydesma* differs widely from that of Dr. Waagen.

In Morris' figures the actual hinge-margin appears to be convexly curved on the anterior side, and slightly sigmoidal on the posterior.[4] Dana did not figure a complete hinge. Frech, in his second illustration of *Leiomyalina antarctica*,[5] shows a generally semicircular outline, convex on either side of the umbo, the posterior element forming a wide, downwardly-sweeping curve. In the earlier figure of an articulus[6] the outline is much less convex on the posterior side. All Waagen's figures of cardinal margins are sharply convex on both sides of the umbo.[7]

(*a*) *Hinge-plate.*—Taken as a whole, each hinge-plate is triangular, but unequal sided, massive in comparison to the heavy, thick umbonal regions; in *E. cordatum* it appears to be larger and heavier in proportion in the left than in the right valve.

[1] Waagen—*Loc. cit.*, p. 140.
[2] Waagen—*Loc. cit.*, p. 143.
[3] Boehm—*Loc. cit.*, p. 299.
[4] Strzelecki—*Op. cit.*, Pl. XII.
[5] Frech—Leth. Pal., *loc. cit.*, p. 600, fig. *a*.
[6] Frech—Abhandl. Geol. Specialkarte Preuss. Thüring Staaten, *loc. cit.*, p. 203, fig. 22.
[7] Waagen—Salt Range Fossils, *loc. cit.*, Pls. VI–VIII.

(*b*) *Resilifer.*—This most important functional space is similar in both valves, transversely elongated, concave, and roughly scythe-shaped; it commences in both valves immediately below the apices of the umbones, and in the left valve is anteriorly cut off from the lunule by an ill-defined ridge uniting the umbo with the cardinal fold, but leaving the umbonal apex free; the margins of the resilifer are acute and erect in both valves, and gradually taper off towards the rounded junctions of the dorso-posterior margins. In the right valve the resilifer tapers to a finely drawn out termination beneath the umbo, consequently the umbonal region of the area in the left valve is somewhat wider than in the right.

Morris spoke of the ligamental area as "elongate and almost wholly internal,"[1] bearing numerous resilium furrows, wide, massive, and posterior to the umbos.

This massive area is again seen in Dana's figure of a portion of the hinge of *E. sacculus*, McCoy, sp.[2] Dana says, "the hinge in the left valve is simply a broad, waved surface."

This area is likewise shown by Johnston in the Tasmanian specimens of *E. cordata*, Morris,[3] but the resilium furrows are only indifferently preserved, and in both of Freeh's figures this grooved area is visible.

Dr. Waagen speaks of the "ligament" in the right valve of *E. globosum*, Waagen, as occupying "a sharp, but not very deep groove, which, extending in a somewhat sloping direction backwards, gets by degrees shallower and broader, and has evidently served for insertion of the ligament."[4] It is assumed that "ligament" is used in its old acceptance, and not as distinguished from the term "cartilage." In the left valve of *E. globosum*, Waagen, the "ligament" is held in the upper and broader part of a bifurcating groove, directed posteriorly, and just below the umbo.[5]

c. Byssal Sinus.—The byssal sinus is a very marked feature in the right valve of *Eurydesma*. It extends from the apex of the umbo to the ventral margin of the hinge-plate; slightly curved and obliquely directed posteriorly, forming a moderately deep channel.

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[1] Morris in Strzelecki—*Op. cit.*, p. 275, Pl. XII.
Dana—*Op. cit.*, p. 699, Pl. VII, fig. 8*c*.
[2] Johnston—Syst. Acc. Geol. Tas., Pl. XVII, figs. 2, 3 *a-c*.
[4] Waagen—Salt Range Fossils, *op. cit.*, p. 139.
[5] Dall—Trans. Wagner Free Inst. Sci., 1895, III, Pt. 3, p. 490.

It is shown in Morris' upper figure,[1] which is regarded by us as representing the typical *E. cordatum*.

In making comparisons with *Meleagrina* (Pl. XXVI, figs. 1–3), a distinction is drawn between a byssal sinus and a byssal notch. The sinus is the channel, in the right valve, situated immediately in front of the umbo, leading obliquely downwards and inwards to the interior. The notch is the aperture, larger or smaller, caused by an inflection of the anterior valve margin. Both are present in all small species examined, such as *M. sugillata*, Reeve, or *M. vulgaris*, Schum, and in small specimens of *M. margaritifera*, Linn. (Pl. XXVI, figs. 2 and 3), and its var. *Cummingii*, Reeve, but in fully-grown shells of *M. maxima* it appears to be filled up by a thickening of the test of both valves. On the whole, it may be said that a notch is present in either delicate and thin-shelled species, or the younger conditions of those forms which in maturity become heavy and thick-shelled; through it is protruded the byssus, and when developed to any size, the foot also.

In all individuals of *Eurydesma* we have examined, both large and small, the valves are entirely closed both anterior and posterior to the umbones, leaving no aperture for the protrusion of either byssus or foot. Mr. C. Hedley tells us he was informed by Thursday Island pearlers that these large shells lie on their sides without byssal attachment. The structure of *Eurydesma* leads us to infer that it may have existed in a similar manner. It could not have progressed like *Pecten* and its allies, in which Dr. R. T. Jackson says, "crawling is effected by dragging the shell still lying on its right side, the foot being extended through a special notch in the right valve. From studies of Pecten I am led to believe that a notch is a feature caused by the extension of the foot quite as readily as by the existence of a byssus."[2]

Morris described a "byssiferous canal passing out of the umbones at the margin of the shell."[3] But in the upper figure of his illustration—a right valve—this is shown as a groove extending across the area obliquely from anterior to posterior. It is also to be seen in Dana's illustration of *E. sacculus*, McCoy,[4] and possibly in Johnston's figure of *E. cordata*, Morris.[5] Dana writes:—"In one fine specimen, in which the beak of one valve is broken

[1] Morris in Strzelecki—*Op. cit.*, Pl. XII.
[2] Jackson—Mem. Boston Soc. Nat. Hist., 1890, IV, No. 8, p. 328.
[3] Morris in Strzelecki—*Op. cit.*, p. 275.
[4] Dana in Wilkes—*Op. cit.*, Pl. VII, fig 8c.
[5] Johnston—Syst. Acc. Geol. Tas., Pl. XVII, fig. 2.

half off, there is a tubular cavity (filled with rock) coming up obliquely from between the beaks and passing out anteriorly; and this cavity was probably the byssiferous channel."[1]

In neither of Frech's figures is this canal shown, but Waagen[2] refers to it as a "narrow slit" in the right valve only, but the left valve (*E. globosum*, Waagen) does not appear to enter into the constitution of the byssiferous canal at all. Waagen says :—"The byssal furrow of the right valve is thus left free by the other valve, which this gives room for the passage of the byssus."[3]

Frech's Smooth Surface.—Dr. Frech seems to be the only writer who regards the articulus of *Eurydesma* as divisible into two main regions, the ligamental area proper, and a smooth, flat and broad surface below the latter; this character was used to separate his genus *Leiomyalina* from *Eurydesma* (p. 45). Waagen in his description of the hinge structures of the Indian species referred to *Eurydesma*, did not refer to this smooth surface: it is to be seen in Johnston's figure of *E. cordatum*,[4] and by Boehm is referred to as the "hinge-plate"[5]—with which we are in agreement.

(*c*) *Cardinal Folds, "Teeth" and Inflections.*—The term cardinal fold is used for the so-called teeth in *Eurydesma*, which loosely fit into inflections of the hinge-plate, teeth and sockets in the true sense not being developed.

Boehm remarks[6] :—"One cannot appropriately consider as valve teeth the archings of the shell-margin, and are, therefore, distinctly visible from the outside." . . . . "the projection of the margin of the left valve simply extends over the margin of the right valve."

In *E. cordatum* it is found that in the right valve the cardinal fold rises as a blunt protuberance on the ventral margin of the hinge-plate, projects horizontally and is a continuation of the byssal ridge, which extends diagonally across the entire area from the umbo apex, and which bounds the byssal sinus posteriorly and separates it from the posterior portions of the hinge mechanism—when the valves are in apposition this fold is invisible.

[1] Dana in Wilkes—*Op. cit.*, p. 699.
[2] Waagen—*Op. cit.*, p. 137.
[3] Waagen—*Loc. cit.*, p. 140.
[4] Johnston—*Loc. cit.*, Pl. XVII, fig. 2.
[5] Frech—Centralbl., *loc. cit.*, p. 299.
[6] Boehm—*Loc. cit.*, p. 298.

The cardinal fold of the left valve—the "little wing" of Waagen—is much larger than that of the right, and unlike that of the latter does not project at right angles to the plane of the hinge-plate, but upwards and slightly outwards, or nearly parallel to the plane. The projection is large, heavy, and blunt, on its inner side concave and dorsally ridged and furrowed like the lunular depression. It is this fold which, when the valves are in apposition and closed, is seen to project from beneath the left umbo like a little "ear" or "wing," as Waagen termed it. If the two halves of the articulus of *Eurydesma* be now regarded from the point of view of proportion, the absolute inequality of the valves becomes at once apparent, without any reference to the external aspect, which is at times misleading.

The nearly horizontal cardinal fold of the right valve rests under the concave surface of the fold of the left valve, whilst the upwardly directed fold of the latter in its turn fits into a "chondrophoral"-like depression of the right valve, where it forms a very marked feature. It is situated below the anterior end of the resilifer, is rather spoon-shaped in outline and section, and obliquely inclined; the anterior end abuts against the ridge connecting the umbonal apex with the cardinal fold.

These folds to some extent perform the function of the teeth of other Pelecypoda, but they are no more teeth, strictly speaking, than is the thickened ridge below the anterior end of the resilifer of the left valve in one of the Pearl Oysters—*Meleagrina maxima*, Jameson—which works against a thickened and flattened surface in a corresponding position on the right valve of the same species.

Morris described the presence of a "large obtuse tooth in the right valve, left inconspicuous."[1] Dana speaks of a "large rounded prominence or tooth" in the left valve, fitting into "a depression somewhat anteriorly."[2] To this prominence in the right valve, Stoliczka assigns the name of cardinal tooth:—"One large subconical cardinal tooth in the right valve, somewhat curved upwards, and corresponding to a pit in the left."[3]

This tooth or prominence is shown on the articulus of the left valve of Frech's first figure of *Leiomyalina antarctica*[4]; but in his later figure—

[1] Morris in Strzelecki—*Loc. cit.*, p. 275.
[2] Dana—*Op. cit.*, p. 699.
[3] Stoliczka—*Loc. cit.*, p. 226.
[4] Frech—Abhandl., *loc. cit.*, p. 203, fig. 22.

that of the Hamburg Museum specimen—it is shown on the right valve,[1] although in the letterpress it is spoken of as a "single, very strong hinge-tooth in each valve, as well as the suspicion of a posterior tooth."

Dr. Waagen gave particular attention to the hinge structure of *Eurydesma*. He remarks that the most conspicuous part of the hinge in the right valve of *E. globosum* is a strong and prominent blunt tooth, just below the apex, extending outwards in a nearly horizontal position; it is solid, and more or less spoon-shaped. He also remarks that in the right valve the "'ligamental furrow' is limited below by a ridge which is highest just below the apex, and becomes here tooth-like. It extends not very far backwards, but disappears after a short distance."[2] According to Waagen, this fits into a deep backwardly bifurcating furrow just below the umbo of the left valve, "the lower somewhat more sloping part serves for the reception of the ridge-like sloping cardinal tooth of the other valve."[3]

Frech's statement that a tooth is present in the left valve is not supported by any other author; in fact, Boehm denies the existence of such a dental development.[4]

Dana refers to a "depression somewhat anteriorly [left valve] answering to a large rounded prominence or tooth in the other valve [right], as described by Morris."[5] This is clearly the socket for the reception of the large dental prominence of the right valve. This depression or socket is shown in the right-hand lower figure of *E. cordatum*, in Morris' Plate XII. Stoliczka speaks of it as a "pit."[6]

In Frech's figure of the Hamburg specimen, the socket is represented simply as an inflection of the margin of the hinge-plate.[7]

It will be remembered that in Waagen's description of the right valve-hinge apparatus of his *E. globosum*, is mentioned a ridge-like, sloping cardinal tooth; the socket for the reception of the latter is the lower portion of the subapical bifurcating groove described by him as occurring in the left valve.[8]

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[1] Frech—Leth. Pal., *loc. cit.*, p. 600, *a* up. fig.
[2] Waagen—*Loc. cit.*, p. 139.
[3] Waagen—*Loc. cit.*, p 140.
[4] Boehm—Centralblatt, *loc. cit.*, p. 298.
[5] Dana in Wilkes—*Loc. cit.*, p. 699.
[6] Stoliczka—*Op. cit.*, p. 226.
[7] Frech—Leth. Pal., *loc. cit.*, p. 600, *a*, lower fig.
[8] Waagen—*Loc. cit.*, p. 140.

Waagen apparently considered that the blunt dental prominence of the right valve also fits into a groove of the left articulus. He says:—"Below and somewhat in front of the semicircular prominence of the cardinal margin of the lunula, there is a shallow groove into which fits the flattened spoon-shaped termination of the blunt tooth of the other valve, not as the teeth of the hinges of bivalves generally do, but only being laterally pressed against this groove, whilst the vertically projecting margin of the lunula, which forms a kind of wing, accommodates itself in the excavation which is exhibited by the upper part of the blunt tooth."

8. *Adductor Scar.*—Morris speaks of the "great muscular impression which, instead of being nearly central as in *Avicula* (including *Meleagrina*, Lam.), is placed anteriorly."[1]

We have been able to obtain but little information on this question so far as *E. cordatum* is concerned, and can only assume its position by comparison with that of *E. hobartense*, Johnston, where we have seen a rather distinctly marked adductor scar (Pl. XXII, fig. 2). From this it is considered that this adductor in *Eurydesma* was weak and poorly developed.

In *E. hobartense* it occupies the deepest portion of the valves, and on casts is shown, to some extent, by the high shoulder-like projection seen in the internal casts. The impression extends obliquely across the valve from a high dorso-posterior position to a mid-anterior; below, its outline is sinuous, but the impression expands antero-ventrally, and the slightly impressed margin curves upwards to join the lower termination of the line of pits (p. 59); above, the edge is not defined on the specimen.

The position of this large muscular impression corresponds fairly well with that of *Meleagrina*, although here its position is not constant.

The suggestion that the adductor was weakly developed receives support in that, in *Meleagrina maxima*, Jameson, the scar varies considerably in strength, according to the size and thickness of the valves.

The older authors referred to the adductor scars, but they have never been figured. Morris[2] considered the genus Monomyarian, and said, "its great muscular impression is placed anteriorly." According to Waagen[3]

[1] Morris in Strzelecki—*Op. cit.*, p. 276.
[2] Morris in Strzelecki—*Op. cit.*, p. 276.
[3] Waagen—*Op. cit.*, p. 138.

the impressions are "much like those in *Meleagrina*." In *E. ellipticum*, Waagen, "there is one rather larger but very flat muscular impression of a rather roundish shape not far from the centre of the valve, being, however, yet considerably posterior in its position from a line drawn from the apex to the middle of the ventral margin." [1]

9. *Visceral Retractor Scars.*—On the inner surface of the valves of *Meleagrina maxima*, Jameson, is a series of small scars forming a roughly sigmoidal line extending either from below the anterior end of the resilifer, or from an umbonal pit, downwards to the anterior end of the adductor scar. These scars in linear series are said by Tryon to be those of the mantle retractor muscles.[2] This has been confirmed by dissection. The terminal scars of the series, whether below the resilifer or in the umbonal cavity and in front of the adductor scars, are always larger than the intermediate impressions.

This line is more or less clearly shown in all species of *Meleagrina* we have examined, but the umbonal pit is plainer and deeper in some forms (*e.g.*, *M. margaritifera*, var. *Cumingii*) than in others; it is much more marked in *Pteria macroptera*, Lamk. Dissection shows that this pit is simply the apical impression of the retractor series, and plays a most important part in retaining in position the general viscera of the mollusc; when the animal is entirely removed from the valves the muscle fibres related to this particular scar remain erect—those adherent to the intermediate scars are flat, but their fibres may be seen streaming out through the substance of the mantle. This umbonal muscle is said by Tryon to be the anterior adductor, and is given as a family character of the Pteriidæ (Aviculidæ)—"posterior muscular impression large, subcentral, anterior small within the umbo" [3]; as, however, it does not extend from valve to valve, but gives attachment as already described, it is difficult to see the applicability of the term adductor to it.

The ventral terminal scar of this series, like the superior one, always larger than the intermediate scars, is regarded by Mr. L. G. Seurat as the anterior in *Meleagrina*.[4] From an examination of the Pearl Oyster this does

[1] Waagen—*Op. cit.*, p. 141.

[2] Tryon—Struct. and Syst. Conch., 1884, III, p. 271.

[3] Tryon—*Loc. cit.*, p. 270.

[4] Seurat—L'Huitre perlière, nacre et perles, p. 8, fig. 1.

not appear to be the case, for the muscle adherent to this scar, like that in the umbonal cavity, does not perform the functions of an adductor. Dr. R. T. Jackson, who has made an exhaustive study of the Pteriidæ and Pectinidæ, states that *Pteria* (*Avicula*) possesses only one adductor in the adult—the large subcentral muscle.[1] In the young state the mollusc was dimyarian, the anterior adductor disappearing with age.[2]

In *Eurydesma* there is a similar more or less Z-shaped line of retractor pits, but somewhat differently arranged. The pits commence above with a single or double transversely elongated well-marked pit or pits, rather larger than those succeeding, situated immediately below and near the *posterior* end of the hinge-plate in each valve; these form the head line of the Z. The line of pits then descends either vertically or obliquely for a short distance, and finally turns anteriorly in a long tail of pits. These are, with little doubt, the scars of the retractor muscles of the mantle and the viscera, although proceeding from below the posterior end of the articulus rather than from the more anterior position of the umbonal cavity. This change places the retractor scars in a much more dorsal position in relation to the adductor in *Eurydesma* than it does in *Meleagrina* and its living allies; a study of certain of our figures (Pl. XX, fig. 3; Pl. XXI, figs. 4 and 5; Pl. XXIV, figs. 1 and 2) will render this clear.

In some specimens a single detached pit occurs beyond the head line of the Z-shaped figure, and more posteriorly; the details of the arrangement vary to a slight extent.

A semicircular line of retractor scars also occurs in *Maccoyella*,[3] but as in *Meleagrina*, is wholly anterior to the adductor scar.

These scars have received the attention of previous writers. Morris figured on the interior of the right valve a slightly curved line of unconnected round depressions immediately below the umbonal cavity, the "small muscular impressions."[4] In *E. sacculus*, Dana, instead of this semicircle of depressions, there are, at about the same position, two only, half an inch apart, and supero-posteriorly are four smaller pit-like depressions forming a curved line

[1] Jackson—Mem. Boston Soc. Nat. Hist., 1890, IV, No. 8, p. 282.

[2] Dall in Zittel—Text-book Pal. (Eastman's Ed.), 1890, I, p. 370.

[3] Etheridge—Mem. Geol. Survey N. S. Wales, Pal. No. 11, 1902, Pl. III, fig. 5.

[4] Morris in Strzelecki—*Loc. cit.*, p. 276, Pl. XII, upper figure.

half an inch long.[1] Similar pits are described by Waagen in his *E. ellipticum*. He says:—"Besides this large muscular impression there is a number of smaller but much deeper ones, which are arranged in a curved line from the anterior part to near the apex, and from these again descending for a short distance in the direction of the posterior part. Towards the anterior region several of them are united, forming on the cast a high crenulated crest. Then follow, somewhat lower in position, three or four single ones. At the apex the line makes a sudden bend and then follows again one large impression, with which the whole series terminates, not far from the posterior margin of the large muscular impression described above.[2]

The surface of the lower or ventral margins of the hinge-plates in *Meleagrina maxima*, Jam., and *Malleus matteus*, Linn., are delicately crumpled transversely, and in more than one of our left valves of *Eurydesma cordatum* and in one of *E. hobartense* (Pl. XX, figs. 2, 3, 5) the place of the crumpling is taken by a line of minute pits; these occur on that portion of the hinge-plates corresponding to Frech's "extended smooth surface" in his *Leiomyalina antarctica*.

10. *Pallial Line.*—This has never definitely come under our notice, but is probably indicated by the dark semicircular outline seen in the internal cast of *E. cordatum*, var. *ovale* (Pl. XXI, fig. 4). In the Pteriidæ (Aviculidæ) (—) it is said to be irregularly dotted, but this is not the case in all members of the family—in *Meleagrina maxima*, *M. margaritifera*, var. *Cumingii*, *Pteria macroptera*, &c., dotting or pitting is absent.

11. *Test.*—The test or shell of *Eurydesma* was enormously thickened in the umbonal region, also in the hinge, and highly lamellate. The umbonal region consists of a solid mass having no umbonal cavity, as is the case in so many Pelecypoda—giving rise to a characteristic internal cast with truncate umbonal regions. Below the line of the hinge-plate the test at first gradually and then rapidly decreases in thickness, until at the ventral margins it is comparatively thin. In some specimens the thickness through the combined hinge-plate and umbonal region attains to at least one and a half inches; in a specimen from Yatton, Q., a thickness of one inch has been recorded by one of us.[3]

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[1] Dana in Wilkes—*Op. cit.*, p. 699, Pl. VII, fig. 8*c*.
[2] Waagen—Salt Range Fossils, *loc. cit.*, p. 141.
[3] Etheridge—Geol. Pal. Q'land, &c., 1892, p. 277.

Morris described *Eurydesma* as thick at the umbones,[1] and Dana as very much thickened under the umbo of the left valve; he gave a transverse section across a valve of *E. sacculus* showing a thickness of nearly one and a quarter inches.[2] Waagen refers to the "enormous thickening of the shell substance in the apical region."[3]

The structure of the test in the Pteriidæ is prismatic and nacreous, "the exterior being composed of prismatic cellular substance, and the interior of true nacre."[4] We have been unable to detect the prismatic cellular layer in *Eurydesma*; this may be due to the liability to exfoliation. A section transverse to the dorso-ventral axis taken completely through the ventricose umbonal region and articulus distinctly shows the successive laminæ of the test, the laminæ broadening as the hinge is receded from. Dr. John Quekett figured this laminar structure in the Pearl Oyster,[5] as well as the outer prismatic layer.

The test of *Eurydesma* has undergone considerable alteration, but, notwithstanding this, tangential sections taken at varying depths display near the surface a structure resembling somewhat the peculiar hackly, laminar structure shown in Dr. Carpenter's figure of polished nacre[6]; these roughened undulations are probably the "plications of the animal basis of the shell."[7] There is no cancellated structure in the test of *Eurydesma* as is the case in most of the Spondyli, "the office of the cancelli being to render the shell lighter."[8]

Very different is the shell structure of *Maccoyella*, another member of the Pteriidæ, and although allied to *Eurydesma*, more nearly so to *Meleagrina*. A section of the test of *Maccoyella* taken parallel to the general surface, whether external or internal, affords a most pearly lustre, and shows a series of fusiform or lenticular figures defined only by a difference in colour. Under polarized light the shell sections of both genera give the same reaction, probably that of calcite.

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[1] Morris in Strzelecki—*Op. cit.*, p. 275.
[2] Dana in Wilkes—*Loc. cit.*, p. 699, Pl. VII, fig. 8*d*.
[3] Waagen—Salt Range Fossils, *loc. cit.*, p. 139.
[4] W. B. Carpenter—Rept. Brit. Assoc., I (1844), 1845, p. 20.
[5] Quekett—Lectures on Histology, 1852, p. 298, fig. 182.
[6] Carpenter—*Loc. cit.*, Pl. VIII, fig. 17.
[7] Quekett—*Loc. cit.*, p. 301.
[8] Quekett—*Loc cit.*, p. 300.

This structure is most characteristic of *Maccoyella*, and is visible on the interior of some weathered valves; owing to varying resistance to weathering a more or less lenticular network is produced—nothing of this type has been noticed in *Eurydesma*. The nacreous character of the valves of *Maccoyella* is indicated at once by the sections, whilst the absence of any lustre in the sections of *Eurydesma* points to a subnacreous variety, like the internal layer of *Pinna*, and the greater part of the test of the oyster *(Ostrea)*. On decalcification the whole of the test of *Maccoyella* is dissolved, but in *Eurydesma* a small residue is left, without organic structure. The surface of the valves in *Eurydesma* is subject to exfoliation, and in only a few instances has the actual external surface been seen, and that not very perfectly. The surface was coarsely laminate, and the laminæ concentrically striate. Radii are generally absent. Morris described the surface of *Eurydesma cordata* as "radiately striate" and "indistinctly radiately striated,"[1] and refers to Sowerby's figure in Mitchell's "Three Expeditions, &c."[2] Dana says of the same species, "marked with concentric lines of growth and low ridges and also with faint radiations." In *E. globosa*, Dana, *E. elliptica*, Dana, and *E. sacculus*, Dana, the author remarks that there is no radial marking.

Only in the specimens referred to above have we met with any traces of radii—in relatively few cases have true external surfaces been seen. Within the lunular depression and on the anterior slopes the edges of the laminæ are very coarse, roughening the surface.

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[1] Morris in Strzelecki—*Loc. cit.*, p. 276.

[2] Sowerby in Mitchell—*Loc. cit.*, Pl. II, fig. 1.

IV.—AFFINITIES OF EURYDESMA, AND COMPARISON WITH OTHER GENERA.

Morris said *Eurydesma* "ought to be arranged very near to *Avicula*"[1] [Pteriidæ]; Dana saw another relationship—"there are some analogies to the shell of a Hippopus [Tridacnidæ], and also to that of a Meleagrina"[2] [Pteriidæ]. Stoliczka, no doubt misled by the supposed "gaping" lunule and the "strong cardinal tooth," believed in "a relation of the genus to *Tridacna* and *Hippopus*."[3] Frech placed *Eurydesma*, as *Leiomyalina*, near *Myalina* [Myalinidæ], but Waagen[4] supported the opinion of Morris, "more to an affinity with *Avicula* or the like, more than with any other shell." He also suggested a comparison with *Aucella*.

Eurydesma appears to us to demand a comparison with two genera in particular—*Meleagrina* and *Maccoyella*, and to some extent with a third, *Aucella*.

(1) *Meleagrina*.—In well-grown examples of either *M. maxima* and its variety, *Cumingi*, or *M. margaritifera*, good types of the genus, the valves are separated along the dorsal margins, leaving a longitudinal wedge-shaped gape or area bearing on its sides the remains of valve attachment fibres, now functionless. The actual line of contact is along the ventral edges of the hinge-plates, interrupted in the centre by the semicircular downwardly-protruding edge of a spoon-shaped depression, extending across the area from anterior to posterior. On the contact margins, and in the concealed portion (when the valves are closed) of the spoon-shaped process, the attachment fibres are functional. Were the longitudinal wedge-shaped gape, or area, filled with the attachment fibre mass, the latter, according to Dall's terminology, would be called the "ligament," and the concealed more linear portion along the line of junction of the valves would become the "resilium," and the spoon-shaped process the "resilifer."

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[1] Morris in Strzelecki—*Op. cit.*, p. 275.

[2] Dana in Wilkes—*Op. cit.*, p. 700.

[3] Stoliczka—Cret. Pelecyp. India, *loc. cit.*, p. 226.

[4] Waagen—Salt Range Fossils, *op. cit.*, p. 138.

In the fresh and perfect mollusc the wedge-shaped area is not filled with uniting fibres, but remains open, its sides often becoming encrusted with small marine growths. A resilium, rather than a ligament, from our point of view, exists in *Meleagrina*, or what may, perhaps, be described as a "retiring resilium"—a resilium the functional area of which always keeps pace and always remains coincident with the line of valve articulation, the upper or dorsal portions becoming atrophied aad functionless.

Eurydesma differs from this arrangement in possessing an entirely concealed or true resilium and a transversely elongated resilifer, in which the entire resilium is contained. The valves do not gape along the dorsal margin, but are tightly closed.

Both genera possess a well-marked byssal sinus, anterior to the umbones in *Meleagrina*, and also in *Pteria*, but posterior in *Eurydesma*. A byssal notch is also present in young individuals of the larger *Meleagrinæ*, and in the small species, but is wanting in *Eurydesma*.

Mantle retractor scars are present in both *Meleagrina* and *Pteria* on the one hand and in *Eurydesma* on the other, but there is a very marked and peculiar difference between the two former genera and *Eurydesma*. In *Meleagrina* and *Pteria* the scars are situated anteriorly to the large adductor scar, but in *Eurydesma* they are on the posterior side of the adductor scar. The umbonal scars so well marked in *M. maxima*, var. *Cumingii*, and in *Pteria macroptera*, and which hold the general visceral mass in position, are not developed in *Eurydesma*, unless a homologue exists in the deepish pit at the dorso-posterior end of the Z-shaped line of scars. The shifting of the retractor scars from the anterior to the posterior is very remarkable in this genus.

The remaining features in which the two genera resemble one another are (*a*) the plain pallial lines; (*b*) inequality of the valves, arising more from structural details, and far less from mere ventricosity of the valves in *Eurydesma* than in *Meleagrina*; (*c*) the presence in *Meleagrina* of a series of delicate undulations along the ventral edge of the hinge-plate, best seen in *M. maxima*—this condition in *Eurydesma* is represented by a line of small pits on the posterior side.

(2) *Maccoyella*.—In internal structure *Eurydesma* possesses practically the same affinity to *Maccoyella* as it does to *Meleagrina*. In the former there

is a similar dorsal gape, and, possibly, therefore a retiring resilium existed; the byssal sinus is anterior to the right umbo, and the mantle retractor scars anterior to the adductor. Too little is known of the condition of this adductor scar in *Eurydesma* to show whether it be single or double, but in *Maccoyella* it was certainly double in some individuals. The details of the articulus of *Maccoyella* more closely resemble those of *Eurydesma* than they do *Meleagrina*.

(3) *Aucella*.—Dr. Waagen compared the hinge mechanism of his *Eurydesma globosum* to that of *Aucella*. He suggested that what is here called the "cardinal fold" in the right valve of *Eurydesma* is analogous to the small, deeply divided-off wing of the right valve of *Aucella*. It may be the case, but in the left valves of the two genera there is a further similarity—for in *Eurydesma* it sometimes happens that the anterior end of the left cardinal fold, as a small rounded projection, protrudes against the right valve. In the Australian Cretaceous *Aucella hughendenensis*, Eth. sp., there is a similar inward inflection of the margin of the left valve.

Professor F. J. Pompeckj has recently made a most detailed examination of the genus *Aucella*.[1] Owing to the lack of specimens of the exotic species, we are unable to follow his observations as closely as we could wish, but there appear to be certain agreements in the hinge-structure of *Eurydesma* and *Aucella*—(1) absence of an anterior adductor scar; (2) absence of teeth; (3) presence of a well-marked byssal groove in the right valve; (4) presence of a resilium [termed ligament by Pompeckj]; (5) a scythe-shaped resilifer behind, in the umbonal regions in some forms.

On the other hand, the cardinal margin appears to gape as in *Meleagrina*; the resilium would therefore be a retiring one, and there is a highly differentiated small auricle in the right valve, and the byssal sinus is anterior to the umbo in the right valve instead of posterior.

It is considered that a reference of *Eurydesma* to either the Tridacnidæ or Myalinidæ may be dismissed without comment, and after an exhaustive comparison with modern forms, the opinions of Morris and Waagen are supported, and the genus placed in the Pteriidæ, and close to *Meleagrina*, the Pearl Oyster, as the nearest living form, and *Aucella* amongst extinct forms. We consider *Eurydesma* to be an offshoot from the *Pteria* stock, greatly restricted in its geological and geographical range.

[1] Pompeckj—Zeit. deuts. Geol. Gesellsch., 1901, XIV, p. 219 *et seq.*

It is not certain, in our opinion, that the fossils from the Salt Range, described and figured by Waagen, and referred to *Eurydesma*, really belong to that genus. They are certainly closely allied, but both the description and figures indicate structures not common to typical forms of *Eurydesma*.

Frech's suggestion that *Sanguinolites Etheridgei*, De Kon., *S. curvatus*, De Kon., *Mytilus Bigsbyi*, De Kon., and *M. crassiventer*, De Kon., may all be referable to *Eurydesma*, has already been referred to (p. 46). There appears to be no evidence in support of the suggestion.

V.—GEOLOGICAL RANGE AND GEOGRAPHICAL DISTRIBUTION

So far as we have been able to ascertain, *Eurydesma* has been found in Tasmania, New South Wales, Queensland, and the Salt Range of India.

The Tasmanian species, *E. cordatum* and *E. hobartense*, occur principally at Maria Island and Porter's Hill, and in the Eurydesma zone near Beaconsfield. It is considered that these localities belong in the main to an horizon which may be correlated with the Lower Marine Series of New South Wales. It is certain that the Maria Island, Beaconsfield, and a great portion, at any rate, of the Porter's Hill Series belong to the Lower Marines, so that *Eurydesma* may be regarded as essentially characteristic of that period in Tasmania.[1]

In New South Wales, *Eurydesma* is known from many localities in the Hunter River Permo-Carboniferous Basin, and in almost all instances from the Lower Marines—Harper's Hill, Allandale, Ravensfield, Pokolbin, and Grass Tree Hill, and in northerly extensions at Kempsey, Warbro and Willi Willi on the Hastings River, Koree, near Wauchope, the head of the Clarence River, near Rivertree.

The occurrence of *Eurydesma* in the Upper Marines has been recorded several times, but only in one case have we been able to corroborate it. In 1905 Mr. C. A. Süssmilch[2] collected specimens of *Eurydesma hobartense* from near Belford, in the railway section from beds mapped by Professor T. W. Edgeworth David[3] as of Upper Marine age. This evidence must be accepted at present, as no faults of sufficient magnitude to admit of Lower Marine beds being brought to the surface at that locality have been found. It may be pointed out that the assemblage of fossils occurring in these *Eurydesma* beds is not directly comparable with those of the adjoining undoubted Upper Marines.

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[1] Johnston—Syst. Acc. Geol. Tas., pp. 119, 124, 126; *Id.*—Trans. R. Soc. Tas. for 1886 [1887], p. 6.

[2] Süssmilch—Proc. Linn. Soc. N. S. Wales, 1906, XXXI, Pt. I, p. 175.

[3] David—Mem. Geol. Survey N. S. Wales, Geol. No. 4, 1907, map.

Morris and Dana recorded *Eurydesma* from "Illawarra," but though this district has been largely collected from, no further specimens have been found; considering the great abundance of *Eurydesma* found in typical localities this is strange, and may probably be due to an error in labelling. Frech recorded[1] *Leiomyalina antarctica* from "Kilama," New South Wales—this probably is meant for "Kiama," a well-known locality in the Illawarra District—Upper Marine. It is suggested that the argument used in connection with Morris' record might be applied to this case also.

With regard to the other New South Wales localities referred to there is no evidence, stratigraphical or palæontological, in favour of their being newer than the Lower Marine Series—so that with one exception we are inclined to regard *Eurydesma* in New South Wales as being characteristic of rocks of the Lower Marine Stage.

In Queensland *Eurydesma* has been collected at Yatton, which must be regarded as of Lower Marine age. Specimens imperfectly preserved, and in all probability referable to *Eurydesma*, have recently been collected by one of us at Gympie—in beds which can be correlated with the Permo-Carboniferous of Northern New England.

[1] Frech—Abhandl., *op. cit.*, p. 201.

VI.—DESCRIPTION OF GENUS AND SPECIES.

Genus—EURYDESMA, *Morris.*

Isocardia, J. de C. Sowerby, Mitchell's Three Exped. Int. E. Austr., 1838, I, p. 15.

Eurydesma, Morris, Strzelecki's Phys. Descript. N. S. Wales, &c., 1845, p. 274.

,, Dana, Wilkes' U.S. Explor. Exped., X (Geol.), 1849, p. 699.

,, Stoliczka, Cret. Fauna S. India (Pal. Indica), 1871, III (Pelecypoda), Pt.5, p. 226.

,, Waagen, Salt Range Fossils (Pal. Indica), 1891, IV, Pt. 2, p. 137.

Leiomyalina, Frech, Abhandl. Specialkarte, Preuss. Thüring. Staaten, IX, Heft 3, 1891, p. 201.

,, Frech, Roemer's Lethæa Pal., II, Lief. 3, 1901, p. 600.

Generic Characters.—Shell large, heavy, obliquely cordate or oval; inequivalve; very inequilateral. Valves convex, usually ventricose, much thickened in the umbonal region; cardinal margin much arched; umbones prominent, prosogyrate, incurved, and acute. Ligament absent, resilium well developed, opisthodetic; resilifer transversely elongate, concave; a prominent cardinal fold rising from the ventral margin of the hinge-plate, and in a vertical line with the umbonal apex, present in both valves, the fold in the right valve fitting under that in the left. Lunule large, cordate, and deep. Adductor scar large, faint, and little impressed; mantle retractor scars well marked, pit-like, and arranged in a Z-shaped line from posterior to anterior; pallial impression very faint, continuous. Structure of test laminar.

TYPE—*Eurydesma cordatum*, Morris

Eurydesma cordatum, *Morris.*

(Pl. XVII; Pl. XVIII, Fig. 1; Pl. XIX, Figs. 3–5; Pl. XX, Figs. 2–5; Pl. XXI, Fig. 1; Pl. XXII, Figs. 3–5; Pl. XXIII, Figs. 1–4; Pl. XXV, Fig. 3.; Pl. XXVI, Fig 4.)

Isocardia (?), J. de C. Sby., Mitchell's Three Exped. Int. E. Austr., 1838, I, Pl. ii, figs. 1–2.

Eurydesma cordata, Morris, Strzelecki's Phys. Descr. N. S. Wales, &c., 1845, p. 276, Pl. xii.

Eurydesma elliptica, Dana, Am. Journ. Sci., 1847, IV (2), p. 158.

„ *globosa*, Dana, *Ibid.*, p. 158.

„ *cordata*, Dana, Wilkes' U.S. Expl. Exped., X (Geol.), 1849, p. 700, Atlas, Pl. viii, figs. 1, 1a.

„ *elliptica*, Dana, *Ibid.*, p. 700, Pl. vii, figs. 6, *a-d.*

„ *globosa*, Dana, *Ibid.*, p. 700, Pl. vii, figs. 7 and 7*a.*

„ *sacculus*, Dana, *Ibid.*, p. 700, Pl. vii, figs. 8*a–e* (non *Pachydomus sacculus*, McCoy).

„ *cordata*, Johnston, Syst. Acc. Geol. Tas., 1885, Pl. xviii., fig. 1*b*, Pl. xix, figs. 1, 1*a.*

Pachydomus globosus, Johnston, *Ibid.*, Pl. xviii, figs. 1, 1*a.*

(?) „ *Koninckı*, Johnston, *Ibid.*, Pl. xviii, fig. 3.

Eurydesma cordata, Eth. fil., Geol. Pal. Q'land, &c., 1892, p. 278.

(?) *Myalina* (*Leiomyalina*) *antarctica*, Frech, Abhandl. Geol. Specialkarte Preuss. Thüring. Staaten, 1891, IX, Heft 3, p. 201, figs. 21–23.

Specific Characters.—Shell obliquely cordate, valves highly ventricose in umbonal region, always produced antero-ventrally to a greater or less extent, sometimes more anteriorly than ventrally, frequently flattened towards the posterior and ventral margins. Test greatly thickened in the umbonal regions; an ill-defined, oblique cincture sometimes present, extending from the postero-ventral margin upwards for about half the height of the shell. Umbones much incurved and overhanging the lunule; umbonal slopes rounded and steep, more particularly the anterior; lunule widely cordate, and deeply excavate. Articulus very massive; resilifer arcuate and tapering posteriorly; cardinal folds and retractor scars as described on pp. 55 and 59. Sculpture concentric, the surface rugged and interlineate, and at times radiate.

Observations.—The large number of specimens now before us conforming to Morris' upper single figure, compels us to regard this as representing the typical form of *E. cordatum*. At the same time this umbonal fragment by no means conveys a correct impression of the actual outline of the species. The collection contains a number of such fragments (Pl. XIX, figs. 4 and 5; Pl. XX, figs. 2, 3, 4, 5), in excellent preservation, and similar portions *in situ* on partially exfoliated individuals, the lower portions being represented by internal casts—the latter are identical in outline, and agree in proportion, with Sowerby's original figure. The dissimilarity of these figures evidently struck Dana, for in referring to them in his synonymy of *E. cordatum* he said, "pl. 12, the second and third figures; also the first?"; his interpretation, however, is opposed to that expressed here.

Considerable variation is represented by *E. cordatum*; from consideration of individual specimens from New South Wales it would be easy to establish three species separable from the type, agreeing with Dana's terminology. If, however, a suite be studied, this separation is seen to be impracticable, the two supposed species, *E. ellipticum*, Dana, and *E. sacculum*, Dana, merging imperceptibly into the species proper, whilst *E. globosum* is merely the young form; under these circumstances all have been brought together under *E. cordatum*, but, as the cincture distinguishing *E. sacculum* does sometimes assume noticeable proportions, the name may be used in a varietal sense. To assist in this enquiry, replicas of Dana's types have been made use of.

The internal cast figured as *Pachydomus Koninckı* (?), by Mr. R. M. Johnston, is a *Eurydesma*, judging from the appearance of the mantle scars, and in all probability belongs to this species. The partially exfoliated shell shown on Johnston's Pl. XVIII, fig. 1b, is this species, but it appears to us that his *Pachydomus globosus*[1] (*non* J. de C. Sby.) is in reality *Eurydesma cordatum*—the deeply excavated and corrugated lunule region differs from that of Sowerby's *P. globosus*.

Leiomyalina antarctica, Frech (1891), is, as already pointed out, a *Eurydesma*, but it is not *L. antarctica*, Frech (1902)—we have no specimens like it.

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[1] Johnston—*Op. cit.*, Pl. XVIII, figs. 1, 1a.

Eurydesma cordatum varies chiefly in the form of the antero-ventral and ventral extension of the valves. In some instances the antero-ventral extension is conspicuous, in others the ventral predominates; in others again, a combination of the two conditions is present, or an anterior is to all intents and purposes absent. In the two valves shown in Morris' lower figures there is a distinct anterior projection—this is an unusual condition, and is shown in one of our specimens. In a few instances the anterior and ventral margins are regularly rounded, whilst a more or less compressed extension occurs posteriorly.

The characters of the umbones are fairly constant, in some examples they appear to touch, in others they are but little separated, and in only one instance are they far apart.

Details of the articulus are given on p. 52, and of the muscular scars on p. 58.

Radial sculpturing is seen on very few specimens.

We have provisionally placed Frech's first figures (1901) of *Leiomyalina antarctica* as a synonym of *E. cordatum*, and we also support Boehm's contention[1] that Frech's 1901 figure represents a shell distinct from the same author's 1902 figures—at the same time expressing uncertainty as to the generic identity of the first-mentioned shell.

Localities.—Allandale, railway, and road cuttings (*C. Cullen, W. S. Dun, T. W. E. David*); Harper's Hill (*C. Cullen*); Mount View, Cessnock (*C. Cullen, W. S. Dun, A. Richter*); Grass-tree Hill, County Durham (*C. Cullen*); Portion 8, Parish Stanford, County Durham, (*W. S. Dun*); Portion 32, Parish Koree (*T. McDonough*); M.L. 1, Parish Koree (*J. E. Carne*), and three miles from Wauchope, County Macquarie (*C. Laseron*); head of Clarence River, below Rivertree (*E. C. Andrews*); Hastings River (*W. J. Gracie*); Kempsey District (*A. E. Rudder*); Parishes Willi Willi, Warbro, and Parrabel, County Dudley (*C. Cullen*)—Permo-Carbouiferous, Lower Marine Series. Willangi, near Broad Sound, Queensland (*T. W. E. David*); Gatton, Queensland — Permo-Carboniferous. Maria Island, Tasmania (*R. M. Johnston*); also at Middle Arm Creek, Beaconsfield, Cheshunt (*R. M. Johnston*)—Permo-Carboniferous, Lower Marine Series.

Collections.—Mining and Geological Museum, Australian and Technological Museums.

[1] Boehm—Centralblatt., *loc. cit.*, p. 297.

Eurydesma cordatum, *Morris*, var. sacculum, *Dana*.

(Plate XIX, Figs. 1 and 2; Pl. XX, Fig. 1; Pl. XXIV, Figs. 1 and 2.)

Eurydesma sacculus, Dana, Wilkes' U.S. Explor. Exped., Geol., X, 1849, p. 700, Pl. vii, figs. 8, *a–e* (non *Pachydomus sacculus*, McCoy.)

Notomya Gouldi, R. M. Johnston, Syst. Acc. Geol. Tas., 1882, Pl. xvii, fig. 1.

Eurydesma sacculus, Eth. fil., Geol. Pal. Q'land., &c., 1892, p. 273 (excl. first syn.).

Observations.—A very variable feature on the valve flanks of *E. cordatum* is a shallow eineture extending usually from the rounded postero-ventral marginal junctions some little distance in the direction of the rounded diagonal ridges, or it may be situated more anteriorly; at times the only indication of this eincture is a flattening of the valve surfaces. Dana's illustration of his *E. sacculus* represents an extreme development of the einctures, and Johnston's figure of *Notomya Gouldi* a still greater.

The figure of *Notomya Gouldi* also illustrates the ventral extension of the valves already referred to.

Localities.—Allandale, near West Maitland—Permo-Carboniferous, Lower Marine Series. Bridgewater, Tasmania (*R. M. Johnston*)—Permo-Carboniferous, Lower Marine Series.

Collections.—Mining and Geological Museum; Australian Museum.

Eurydesma cordatum var. ovale, *Eth. fil. & Dun.*

(Plate XXI, Figs. 4 and 5; Pl. XXV, Figs. 1 and 2.)

Observations.—We apply this varietal name to a form intermediate between the typical condition of *E. cordatum* and *E. hobartense*. It is more truly oval in outline than the species in chief, and usually less robust and ventricose, thereby approximating to Johnston's Tasmanian species. It is also restricted, so far as we at present know, to a particular horizon in the Lower Marine Series—the Ravenswood Sandstone, separating the Farley and Lochinvar Stages.

Localities.—Ravensfield Quarry (*C. Cullen, T. Browne*): Ravensworth Quarry (*W. S. Dun*)—Permo-Carboniferous, Lower Marine Series.

Collection.—Mining and Geological Museum.

Eurydesma hobartense, *Johnston.*

(Plate XVIII, Figs. 2 and 3; Pl. XX, Fig. 6; Pl. XXI, Figs. 2 and 3; Plate XXII, Figs. 1 and 2; Pl. XXIII, Fig. 5; Pl. XXIV, Fig. 3; Pl. XXV, Figs. 4 and 5.)

Pachydomus hobartensis, Johnston, Syst. Acc. Geol. Tas., 1882, Pl. xvi, fig. 2.

(?) *Eurydesma cordata*, Johnston (*non* Morris), *Ibid.*, Pl. xvii, figs. 2, 3, 3*a* and *b*.

Leiomyalina antarctica, Frech, Roemer's Lethæa Pal., 1902, II, Lief. 4, p. 600, fig. *a*.

Eurydesma cordata, Süssmilch, Proc. Linn. Soc. N. S. Wales, 1906, XXXI, Pt. 1, p. 175.

Specific Characters.—Shell obliquely oblong-ovate; valves convex, but not ventricose, may be produced ventrally; umbones acute, overhanging the lunule; umbonal slopes rounded, not steep. Lunule well marked, but not deeply excavate. Articulus as in *E. cordatum*, but much less massive, the hinge-plate narrow. Cinctures not observed. Adductor scars as described on p. 58. Retractor scars as in *E. cordata*. Sculpture concentric, no radii seen.

Observations.—The separation of this shell from *E. cordata* is merely a question of degree—the general structure is the same, but all the parts are on a less massive scale. The valves are far less ventricose, the depth through the conjoined valves being not nearly as great as in *E. cordata*. An examination of the articuli as shown in figures published by Johnston and Frech, mentioned in the synonymy, and those now published (Pl. XX, fig. 6; Pl. XXI, fig. 2), and comparison with those of corresponding regions in *E. cordata* (Pl. XIX, fig. 5; Pl. XX, figs. 2, 3, 5) will at once show the much less massive structures of the hinge regions in *E. hobartense*.

Professor Boehm, during his visit to Tasmania, collected extensively from the Eurydesma beds, and noticed the similarity of Frech's 1902 specimens to his own material.[1]

One of the specimens of this form furnishes the only example in which the large adductor impression is preserved—this is described on p. 58.

Localities.—Maria Island, Tasmania—Permo-Carboniferous, Lower Marine Series; Railway Cutting, near Belford, N. S. Wales (*C. A. Süssmilch, W. S. Dun, C. Cullen*)—Permo-Carboniferous, Upper Marine Series.

Collections.—Mining and Geological, Technological, and Australian Museums.

[1] Boehm—*Loc. cit.*, p. 297.

PLATES AND EXPLANATIONS.

Specimens are drawn natural size, either by or under the supervision of Mr. A. R. McCulloch, Australian Museum.

PLATE XVII.

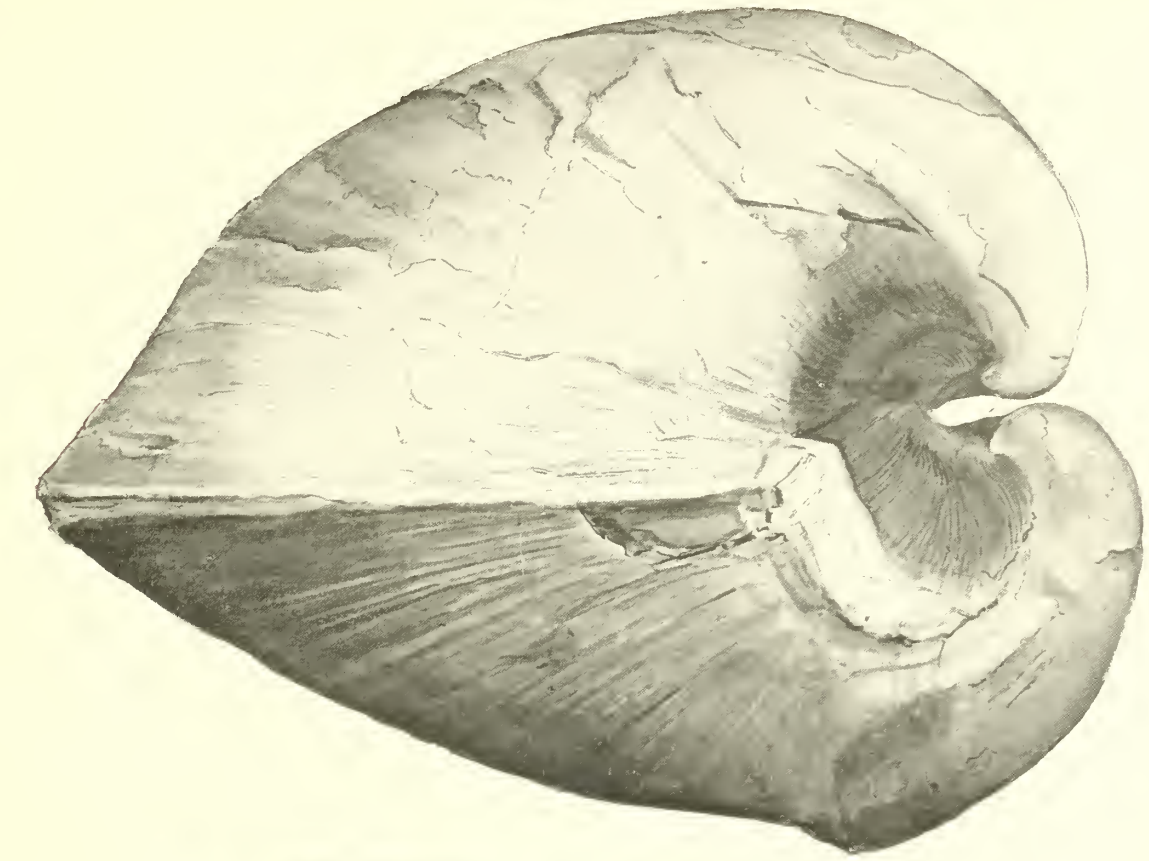
Eurydesma cordatum, *Morris.*

Fig. 1. A large example of the united valves, anterior view. The umbonal region of the left valve is seen to project above that of the right ; the deep cordate, lunular depression is also well displayed.

Fig 2. Dorsal view of the same specimen (Fig. 1), showing the closed valves.

Locality.

Allandale, near West Maitland.



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2

PLATE XVIII.

Eurydesma cordatum, *Morris.*

Fig. 1. Lateral view of the right valve of the specimen Plate XVII, exhibiting in a still more marked manner the projection of the left umbonal region; the general cordate outline and posterior extension of the valves is also in evidence.

Eurydesma hobartense, *Johnston.*

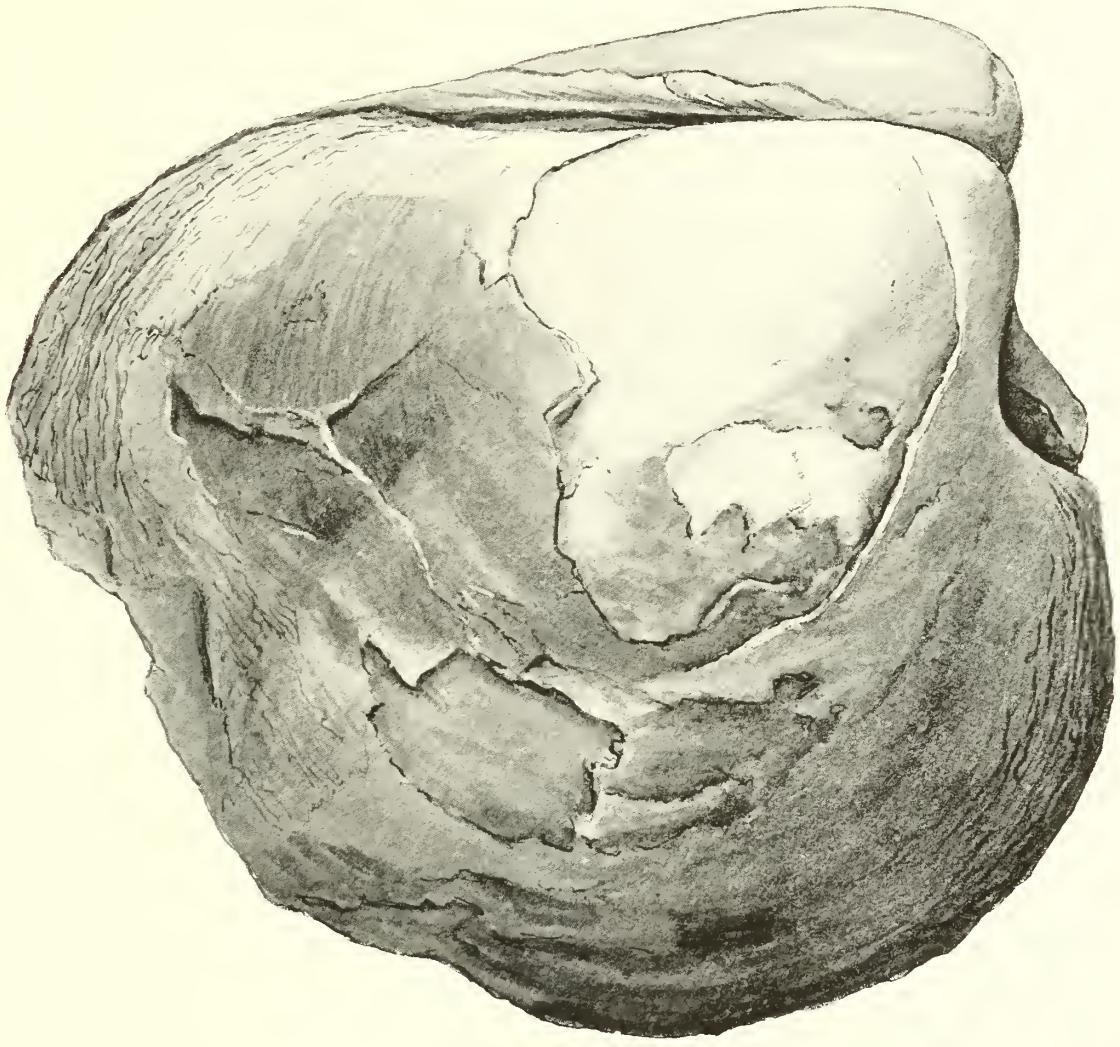
Fig. 2. Testiferous left valve.

Fig. 3. Dorsal view of the united valves displaying an abnormal width between the umbones, the byssal groove under the right umbo, an unusual rugosity in the flattened lunular depression, and inequality of valves.

Localities.

Fig. 1. Allandale, near West Maitland.

Figs. 2, 3. Maria Island, Tasmania.



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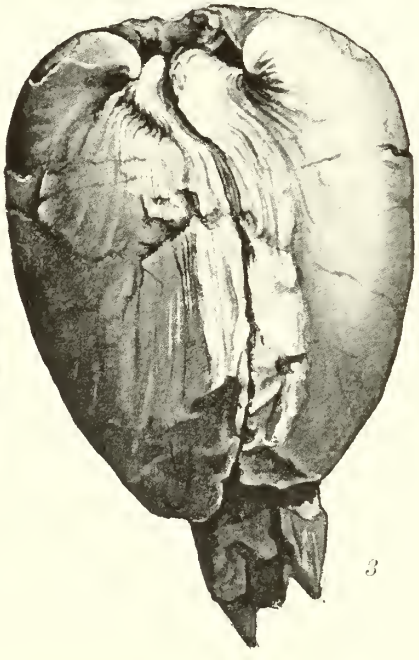

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PLATE XIX.

Eurydesma cordatum, var. sacculum, *Dana.*

Fig. 1. Medium sized, cordate, testiferous right valve, exhibiting the cincture typical of the var. *sacculum.*

Fig. 2. Dorsal view of Fig. 1, showing almost equal umbones and the valves closed along the cardinal margins.

Eurydesma cordatum, *Morris.*

Fig. 3. Partially testiferous united valves, with the left umbonal region again projecting above that of the right valve. The anteriorly directed and incurved umbones, the deep lunular depression, and the cardinal fold of the left valve are also visible.

Fig. 4. Articulus of a right valve displaying the deep byssal groove in the lunular depression, and the scythe-shaped resilifer posterior to the umbo.

Fig. 5. Portion of another right articulus, with the projecting cardinal fold and other features seen in Fig. 4.

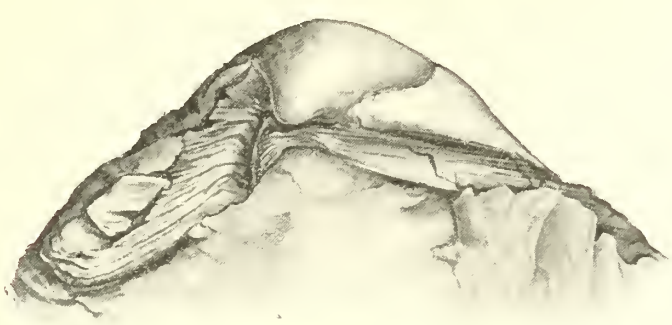
Localities.

Figs. 1, 2. Allandale, near West Maitland.

Fig. 3. Harper's Hill, near West Maitland.

Fig. 4. Harper's Hill, ,,

Fig. 5. Allandale, near West Maitland.



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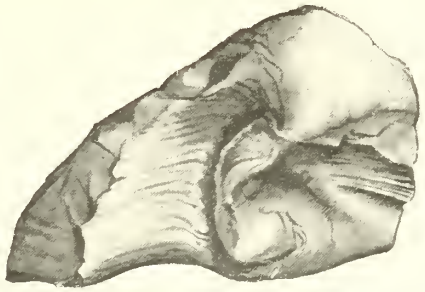

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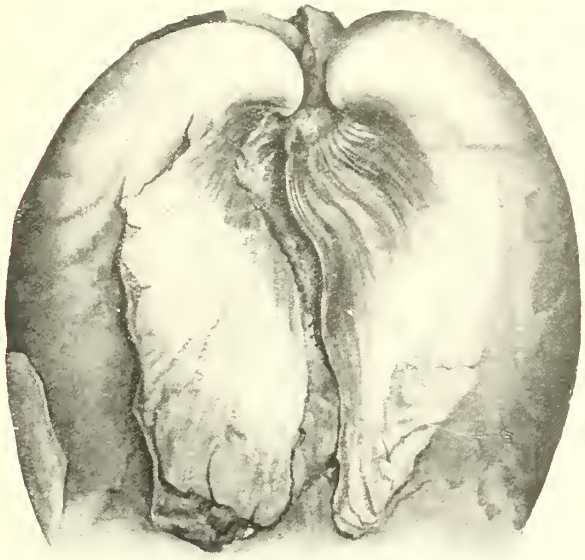

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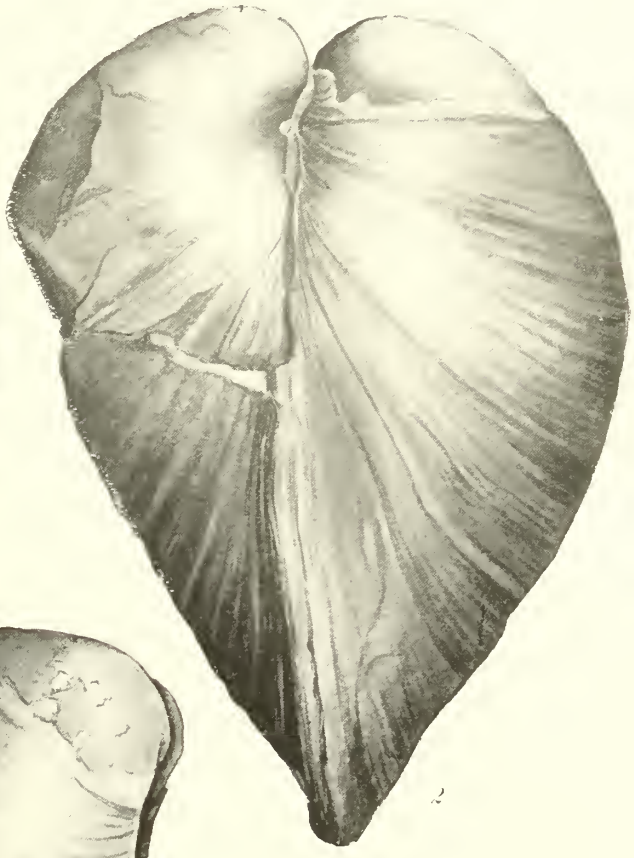

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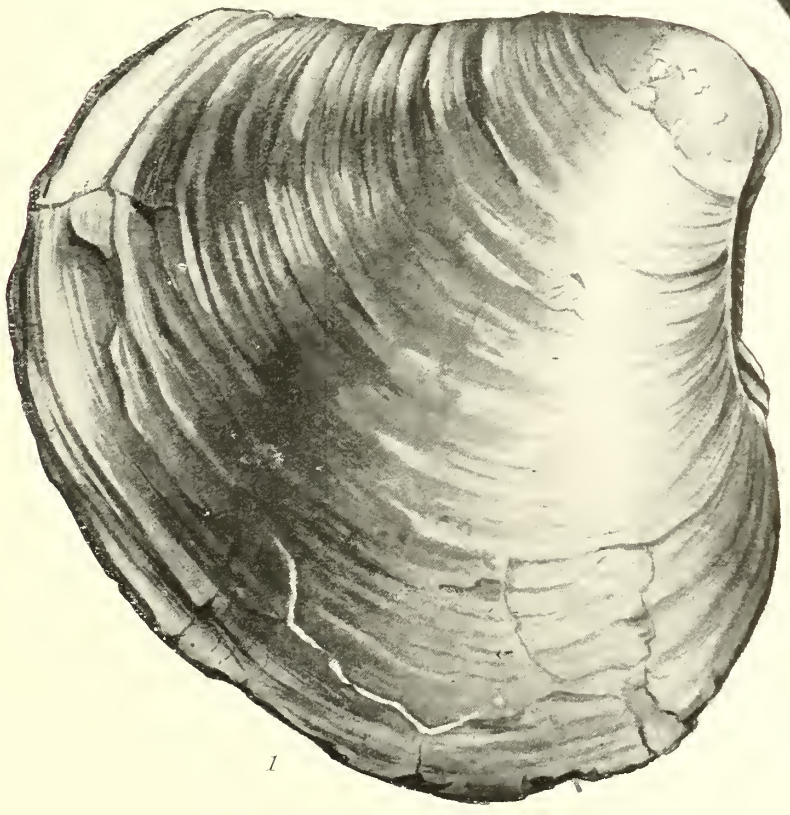

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PLATE XX.

Eurydesma cordatum, var. sacculum, *Dana.*

Fig. 1. Left valve of a much ventrally produced example, partly testiferous, the anterior margin nearly vertical.

Eurydesma cordatum, *Morris.*

Fig. 2. Umbonal region and articulus of a left testiferous valve displaying a portion of the resilifer, and below it Frech's smooth space, bearing a row of minute muscular impressions or pits ; on the right, beneath the umbo, is visible the cardinal fold, and again below it the inflection for the reception of that of the right valve.

Fig. 3. A more directly interior view of Fig. 2, with the visceral retractor scars shown in addition to the features of Fig. 2.

Fig. 4. Right valve, more or less decorticated.

Fig. 5. A similar specimen to Fig. 2 (see Pl. XXVI, fig. 4).

Eurydesma hobartense, *Johnston.*

Fig. 6. Interior of a portion of a testiferous left valve (see Pl. XXII, fig. 2, and Pl. XXIII, fig. 5) displaying the long, slender resilifer, cardinal fold, inflection for the reception of that of the right valve, and the retractor scars.

Localities.

Fig. 1. Allandale, near West Maitland.

Figs. 2, 3. Harper's Hill, ,,

Fig. 4. ,, ,,

Fig. 5. Allandale. ,,

Fig. 6. Maria Island, Tasmania.

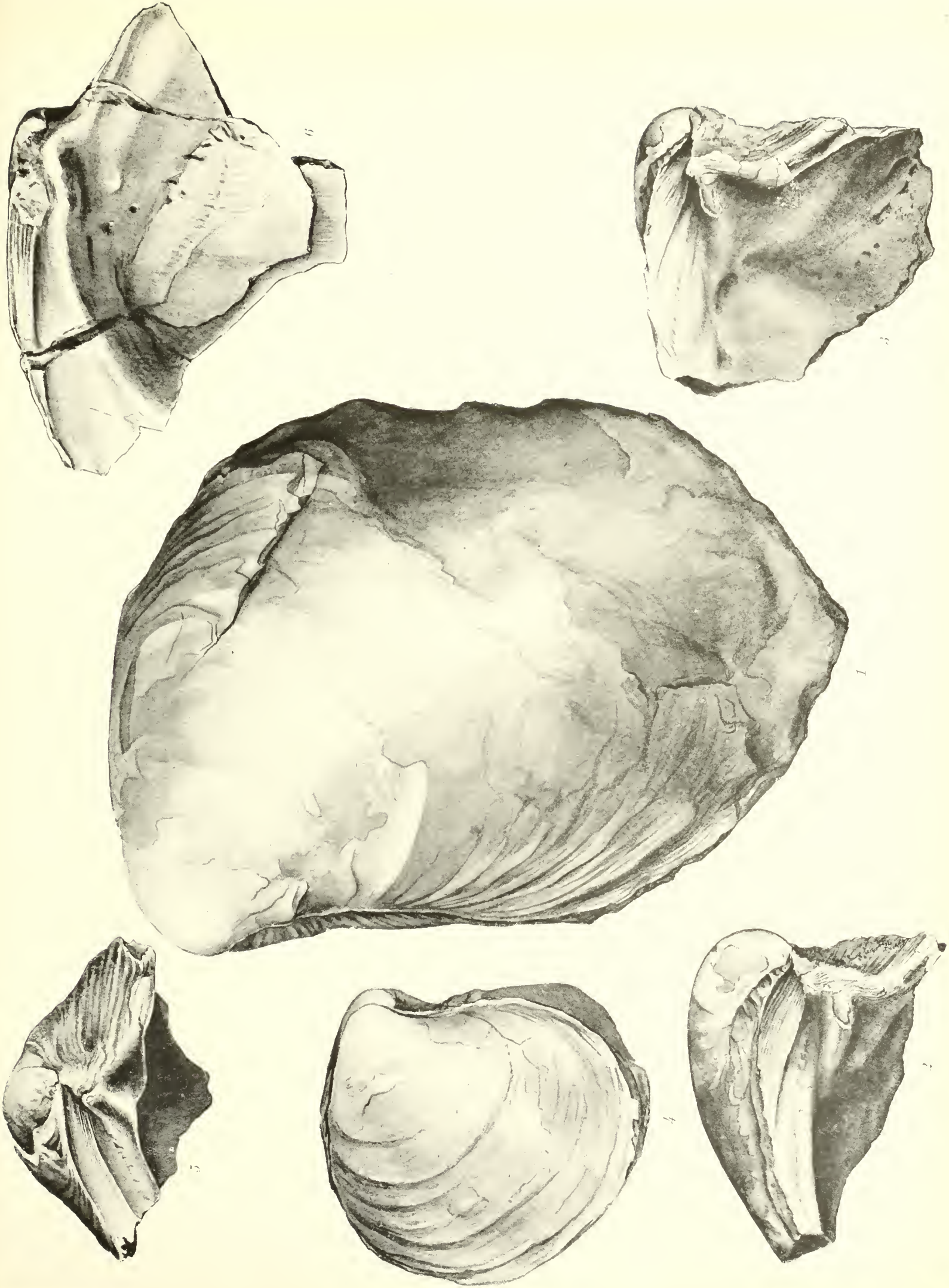


PLATE XXI.

Eurydesma cordatum, *Morris.*

Fig. 1. Partly testiferous left valve with a produced umbonal region.

Eurydesma hobartense, *Johnston.*

Fig. 2. Interior of rather more than half a testiferous left valve with a nearly complete resilifer, small cardinal fold, and large inflection for the reception of the fold of the right valve; the interior is filled with limestone.

Fig. 3. Umbonal region and articulus in part of a testiferous left valve (see Pl. XXII, fig. 1; Pl. XXIII, fig. 5), displaying a highly produced anterior end, a flattened lunular depression, and portion of the resilifer.

Eurydesma cordatum, var. ovale, *E. & D.*

Fig 4. Internal cast of a right valve, exhibiting the casts of the resilifer, cardinal inflection, visceral retractor scars, radii, and undefined pallial impression.

Fig. 5. A smaller internal cast of a right valve (see Pl. XXV, fig. 2) displaying the sharp, cardinal margin, and line of visceral retractor scars.

Localities.

Fig. 1. Mount View, near Cessnock.

Figs. 2, 3. Maria Island, Tasmania.

Figs. 4, 5. Ravensworth Quarry, near West Maitland.

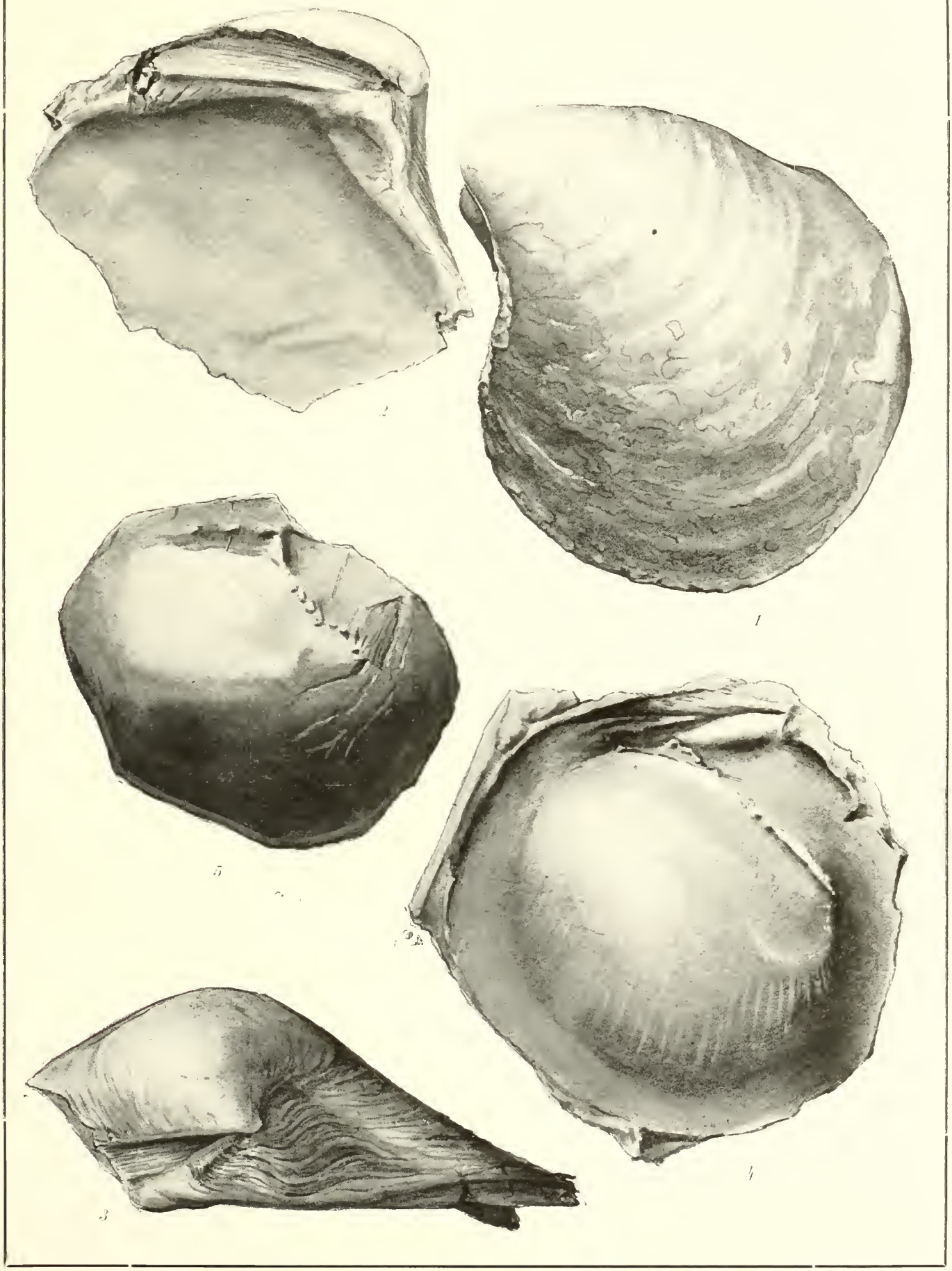


PLATE XXII.

Eurydesma hobartense, *Johnston.*

Fig. 1. Portion of a testiferous left valve (see Pl. XXI, fig. 3 ; Pl. XXIII, fig. 5) showing a produced anterior end.

Fig. 2. Internal cast of a left valve (see Pl. XX, fig. 6 ; Pl. XXIII, fig. 5) exhibiting radii, portion of the resilifer, inflection for the reception of the right cardinal fold, visceral retractor scars, and that of the adductor.

Eurydesma cordatum, *Morris.*

Fig. 3. Anterior view of the umbonal region of a left valve displaying a greatly thickened test, as evinced by the width between the umbo and the cardinal margin.

Fig. 4. Right valve of a very young testiferous individual.

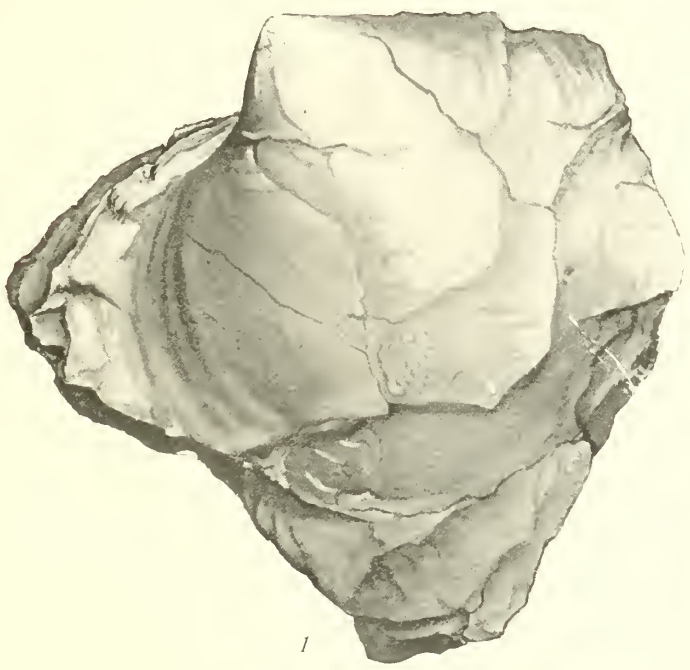
Fig. 5. Anterior view of the conjoined valves of Fig. 4, the umbonal region of the left valve projecting above that of the right.

Localities.

Figs. 1, 2. Maria Island, Tasmania.

Fig. 3. Allandale, near West Maitland.

Figs. 4, 5. Harper's Hill, near West Maitland.



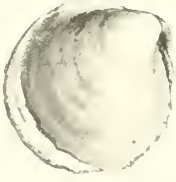


PLATE XXIII.

Eurydesma cordatum, *Morris.*

Fig. 1. Right valve of a large specimen, partly testiferous, but with a less marked external inequality of the valves.

Fig. 2. Testiferous umbonal region and articulus of a right valve exhibiting a large resilium, Frech's smooth space, byssal sinus, and horizontally projecting cardinal fold.

Fig. 3. Right valve of a young shell (reproduction of the type of *E. globosa*, Dana in Wilkes—U.S. Explor. Exped., Geol., X, Pl. VII, fig. 7).

Fig. 4. United valves of Fig. 3, anterior view (Dana in Wilkes, *loc. cit.*, fig. 7*a*).

Eurydesma hobartense, *Johnston.*

Fig. 5. Portion of a testiferous left valve (see Pl. XX, fig. 6; Pl. XXII, fig. 2.)

Localities.

Fig. 1. Maria Island, Tasmania.

Fig. 2. ,, ,, ,,

Figs. 3, 4. Harper's Hill, near West Maitland.

Fig. 5. Maria Island, Tasmania.

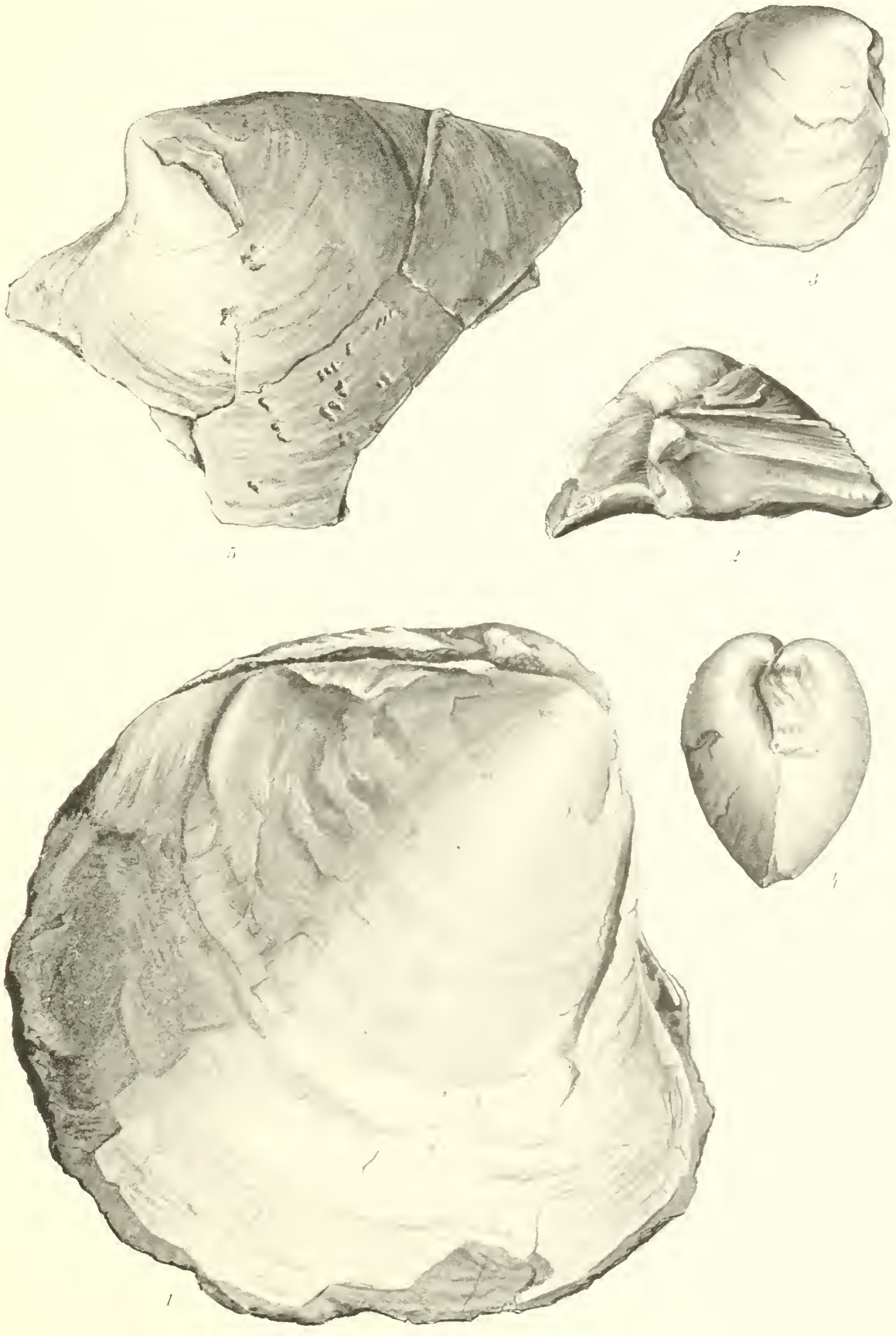


PLATE XXIV.

Eurydesma cordatum, var. sacculum, *Dana.*

Fig. 1. Internal cast of the united valves displaying the characteristic ventricosity of the valves, the cardinal margins, and the visceral retractor scars.

Fig. 2. Right valve of Fig. 1.

Eurydesma hobartense, *Johnston.*

Fig. 3. United testiferous valves, the left umbo projecting above that of the right, and a further inequality is shown by the rapid decrease in convexity of the left valve towards the ventral border.

Localities.

Figs. 1, 2. Allandale, near West Maitland.

Fig. 3. Maria Island, Tasmania.

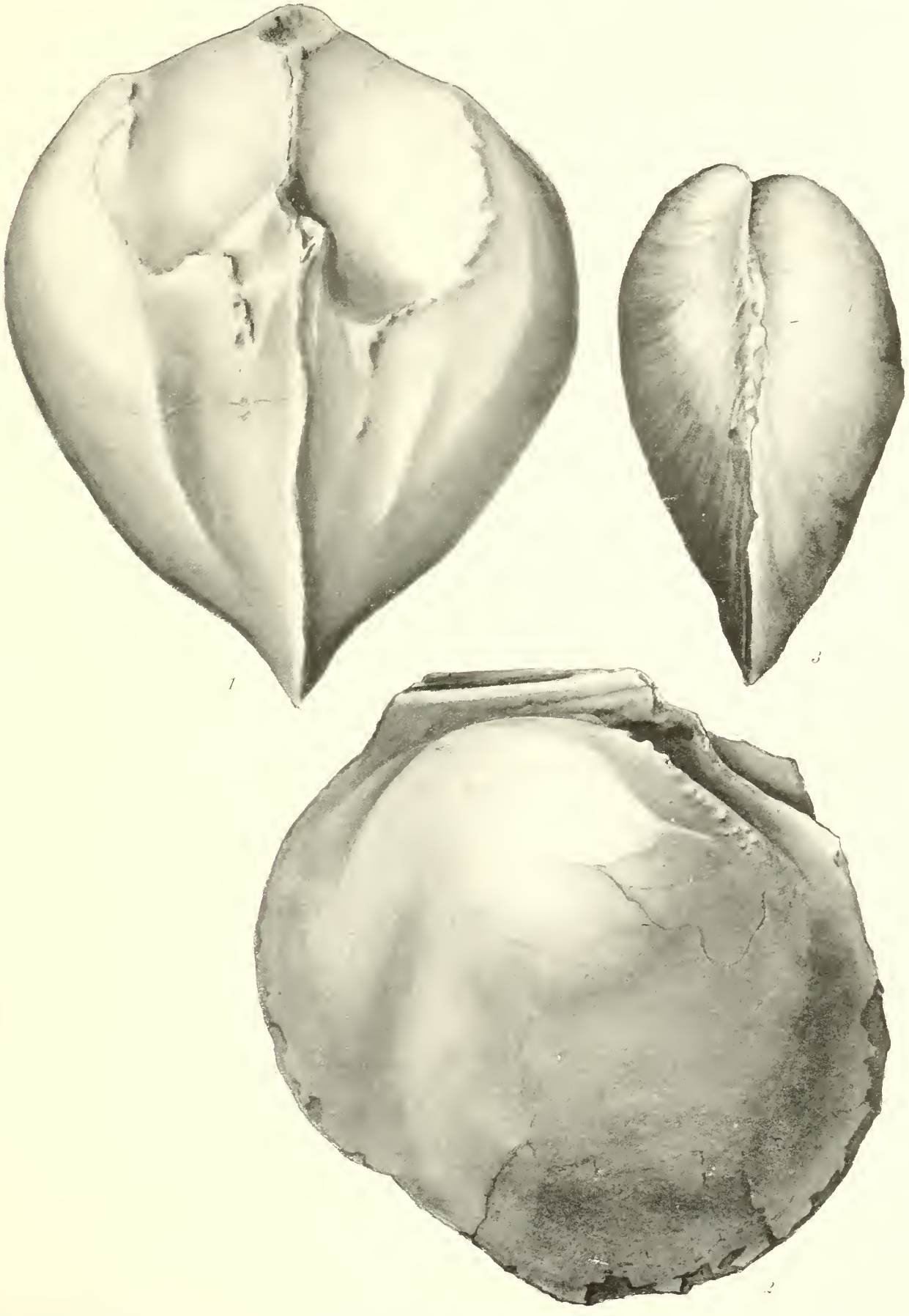


PLATE XXV.

Eurydesma cordatum, var. ovale, *E. & D.*

Fig. 1. Left valve, testiferous in part.

Fig. 2. Dorsal view of the united valves of Pl. XXI, fig. 5.

Eurydesma cordatum, *Morris.*

Fig. 3. Right testiferous umbonal region and articulus, displaying a highly prosogyrate umbo, deep byssal groove, resilifer, Frech's smooth space, cardinal fold, and lunular depression.

Eurydesma hobartense, *Johnston.*

Fig. 4. Portion of a testiferous left valve with an extended anterior end.

Fig. 5. Interior of Fig. 4, with a portion of the resilifer, and line of visceral retractor scars.

Localities.

Fig. 1. Ravensfield Quarry, Farley.

Fig. 2. „ „ „

Fig. 3. Allandale, near West Maitland.

Figs. 4, 5. Maria Island, Tasmania.

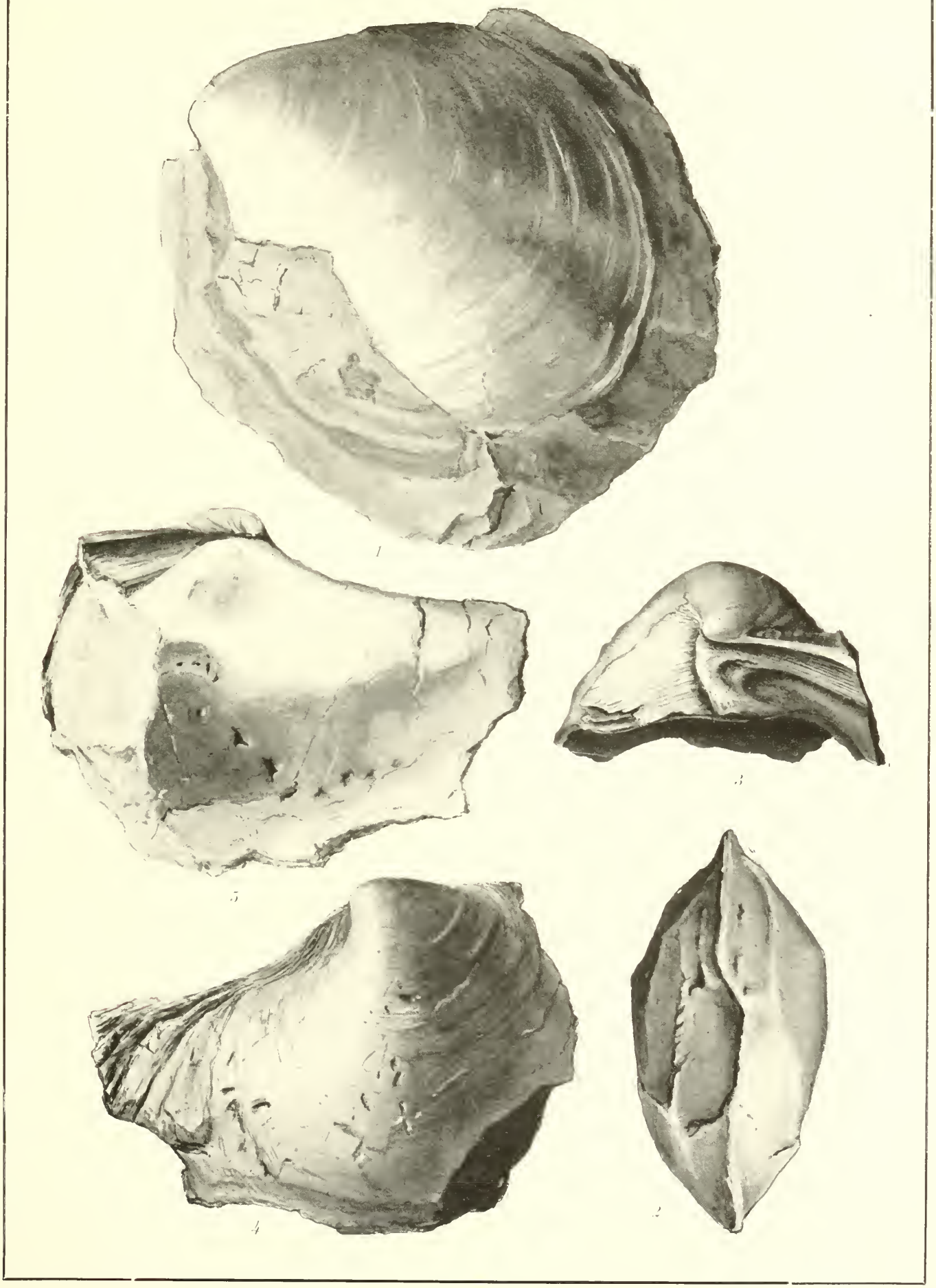


PLATE XXVI.

Meleagrina margaritifera, *Linn.*, var. Cumingii, *Reeve.*

Fig. 1. Portion of the interior of a right valve, showing the hinge-plate, resilifer, byssal sinus, adduct or impression and visceral scars.

Fig. 1a. Dorsal portion of a left valve, exhibiting the hinge-plate, resilifer, and byssal sinus.

Meleagrina margaritifera, *Linn.*, var. typica, *Jamieson.*

Fig. 2. Anterior view of opposed valves, displaying the dorsal gape, byssal sinus, and byssal notch.

Fig. 3. Dorsal view of the apposed valves, with the dorsal gape and byssal notch.

Eurydesma cordatum, *Morris.*

Fig. 4. Portion of a left valve, showing the hinge-plate, resilifer, cardinal fold, and Z-like line of visceral muscle scars (see Pl. XX, fig. 5.)

Locality.

Fig. 4. Allandale, near West Maitland.

1a

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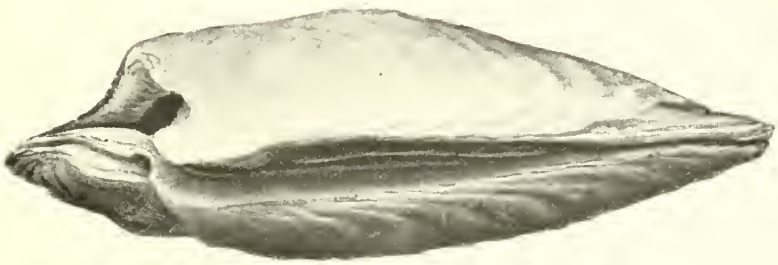

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